Prevention and Treatment of Childhood Obesity

Christine L. Williams, MD, MPH, Maria T. Gulli, MD, and Richard J. Deckelbaum, MD

Address
Institute of Human Nutrition and Department of Pediatrics, Section of GI/Nutrition, Columbia University, College of Physicians and Surgeons, Babies & Children's Hospital, 3959 Broadway, BHN7-702, New York, NY 10032, USA.
E-mail: Chrisw@pol.net

Current Atherosclerosis Reports 2001, **3**:486–497
Current Science Inc. ISSN 1523-3804

Obesity has reached epidemic proportions among children and youth in the United States. Surveys indicate that the number of overweight children aged 6 to 17 years has doubled within three decades. In the decade between the late 1970s and the late 1980s, the prevalence of overweight increased from 7.6% to 10.9% for children aged 6 to 11 years, and from 5.7% to 10.8% for adolescents aged 12 to 19 years. Data for 1999 indicates that the epidemic is continuing to increase, so that 13% of 6- to 11-year-old children and 14% of 12- to 19-year- old children are currently overweight (body mass index ≥95th percentile for age/gender). This article reviews newer concepts related to etiologic factors, comorbidities, and strategies for prevention and treatment.

Introduction

Obesity is the currently the most prevalent pediatric chronic disease in the United States, affecting one out of every seven children. It is also one of the most challenging and frustrating problems facing the adults who nurture and care for children (pediatricians, parents, schools, government officials, nutritionists, exercise physiologists, etc.). It is frustrating because it is difficult to define the problem, difficult to understand its etiology, difficult to predict its natural history over time, and difficult to effectively prevent or treat the condition. In this article, we review current concepts and recent advances in this field as they apply to the prevention and treatment of childhood obesity.

Recent Trends in Rates of Childhood Obesity

Obesity has reached epidemic proportions in the United States in the past several decades. Prevalence rates have increased sharply among adults, reflecting an average weight gain of 8 lb over a single decade. Recent national survey data from the National Health and Nutrition Examination Surveys (NHANES III) indicates that more than one in three American adults are obese [1]. The health implications of this mounting problem are significant, because obesity is a chronic disease that is associated with excess mortality, as well as a large number of comorbidities, such as coronary heart disease, type II diabetes mellitus, hypertension, dyslipidemia, gallbladder disease, respiratory disease, gout, arthritis and some types of cancer [2]. Direct healthcare costs related to obesity annually exceed $68 billion, or about 6% of total healthcare expenditures in the United States [3].

Obesity has also increased dramatically among children and youth in the United States. Surveys indicate that the number of overweight children aged 6 to 17 years has doubled within three decades [4–6]. In the decade between the late 1970s and the late 1980s, the prevalence of overweight increased from 7.6% to 10.9% for children aged 6 to 11 years, and from 5.7% to 10.8% for adolescents aged 12 to 19 years [4–6]. The most recent data for 1999 indicate that the epidemic is continuing to increase: 13% of children aged 6 to 11 years and 14% of children aged 12 to 19 years are currently overweight (body mass index [BMI] ≥95th percentile for age/gender) (Table 1) [7,8].

Surveys in the United States also indicate that the prevalence of childhood obesity has increased even among 4- to 5-year-old preschool children, and in some gender- and ethnic-specific subgroups (*eg*, Mexican-American girls) as young as 2 years of age [9]. The problem is especially acute among minority preschoolers, with highest prevalence rates among Mexican-American children, intermediate rates among non-Hispanic black children, and lowest rates in non-Hispanic white children. Obesity has also increased among low-income preschool children [10]. Currently, almost 8% of 4- and 5-year-old children in the United States are overweight (BMI >95th percentile). This represents a significant increase in the past 20 years, especially among girls. The percent of 4- and 5-year-old girls who were overweight increased from 5.8% in the early 1970s to over 10% recently. Overweight among 4- to 5-year-old boys also increased, but not as much as it had for girls [9].

Childhood obesity is increasing in other countries as well as the United States. Because there is a lack of international

Table 1. Prevalence of overweight* among children and adolescents, aged 6 to 19 years, from 1963 to 1999 in the United States

Age, y	1963–1970, %	1971–1974, %	1976–1980, %	1988–1994, %	1999, %
6–11	4	4	7	11	13
12–19	5	6	5	11	14

*Defined as body mass index greater than 95th percentile (overweight a surrogate for overfat or obese).
Data from Centers for Disease Control and National Center for Health Statistics [8].

agreement on classification of obesity in children and adolescents, however, it is not possible to precisely compare rates of childhood obesity in the United States with other countries in the world. Emerging data from both industrialized and developing countries suggest that the increase in childhood obesity is both global and pandemic. National studies of health and growth in English and Scottish children between 1972 and 1990 show a roughly twofold increase in overweight, affecting all age groups and both genders [11]. In England, preschool obesity has also increased dramatically in the past decade. Bundred *et al.* [12] reported a 60% increase in the prevalence of overweight (BMI >85th percentile) and a 70% increase in the prevalence of obesity (BMI >95th percentile) based on British Growth Reference Charts. Additional reports from the World Health Organization indicate that childhood obesity is increasing worldwide, in developing countries as well as industrialized ones [13–16].

Adverse Health Effects of Childhood Obesity: Physical and Mental Comorbidities

The increase in childhood obesity is of public health concern because it is associated with a significant number of adverse health conditions, both physical and mental, many of which have serious implications for future child health. Some of these adverse conditions are as follows: elevated blood pressure; elevated blood lipids (total and low-density lipoprotein [LDL] cholesterol and triglycerides) and reduced "good" high-density lipoprotein (HDL) cholesterol; elevated fasting blood insulin levels and insulin resistance; glucose intolerance and type II diabetes mellitus; polycystic ovary syndrome; fatty liver (hepatic steatosis) with elevated liver enzymes; orthopedic problems such as bowed tibia, knee, and hip disorders; skin problems, such as acanthosis nigricans and fungal infections; and psychologic problems including depression and withdrawal [17••,18–23]. In addition, asthma is linked to obesity in childhood. In one survey of 171 4- to 16-year-old children, significantly more children with asthma were obese (BMI ≥95th percentile) compared with control patients (30.6% vs 11.6%), and the asthmatic children were significantly more overweight than nonasthmatic control patients [24]. Recent studies have also linked focal segmental glomerular sclerosis (FSGS) of the kidney with childhood obesity, yet another target organ of this chronic disease [25]. In addition, national data on 5305 American children surveyed in the NHANES-III survey indicate that C-reactive protein (CRP) concentration was significantly elevated in children with BMI ≥85th percentile, similar to findings in obese adults. Thus, excess body weight in childhood appears to be associated with a state of chronic low-grade inflammation in children [26].

There is also evidence that obesity is associated with adverse health effects even in the first few years of life. In a survey of 1239 2- to 5-year-old children in nine upstate New York Head Start Centers in 1995 to 1996 (part of a 3-year National Heart, Lung, and Blood Institute [NHLBI]-funded cardiovascular risk-reduction project named "Healthy Start"), 12.1% of the children (aged 3.5 years) had BMI levels above the 95th percentile for age, sex, and ethnicity based on NHANES-III data (16.5% Hispanic, 10.7% black, and 8.8% white). In the "Healthy Start" preschool cohort, 38% of the children had elevated total cholesterol levels, and 21% had borderline-low or low levels of "good" HDL cholesterol [27]. Overweight children had significantly lower levels of HDL cholesterol than leaner children, especially comparing those who were higher than the 95th percentile BMI cutoff with those who were below the 85th percentile. Almost half (44%) of those who were above the 95th percentile cutoff level had low HDL cholesterol levels (less than 35 mg/dL) compared with 31% of those who were below the 85th percentile for BMI. Twelve percent were above the 95th percentile BMI-overweight cutoff point (you would expect only 5%). In addition, BMI was positively and significantly correlated with both systolic and diastolic blood pressure (BP) in this population of predominately low-income minority preschoolers (n=1226). The higher the BMI, the higher the BP. The relative risk (RR) of borderline-high or high systolic BP and/or diastolic BP more than doubled for preschoolers with BMI above the 95th percentile compared with those below the 85th percentile. Thus, obesity affects cardiovascular risk status even in preschoolers.

Childhood obesity also takes a toll on mental health, with reported negative effects on self esteem and peer relationships. Several studies have shown that children are negatively sensitized to obesity at a young age, and develop cultural preferences for leanness. In one study of 10- to 11-year-old children, children preferred handicapped children as friends more so than obese children, and ranked obese children lowest among those with whom they would like to be friends [28]. Others reported that children as young

as 6 to 10 years of age already associated laziness and sloppiness with obesity [29].

Self-esteem is negatively affected by obesity more so in older children and adolescents compared with young children, probably reflecting the increasing role of peers, rather than parents, as sources of self-esteem during adolescence [30]. As obese children grow older, they are less likely than their lean peers to be chosen as "best friend," invited to birthday parties, selected for team sports, or become members of child-initiated clubs. Repeated rejection leads to feelings of withdrawal, unworthiness, passivity, and sometimes depression. Obesity in young women has been shown to be an important determinant of lower socioeconomic status (rather than a consequence), with obese women earning on average earning $6710 less per year, 10% more likely to have income below poverty level, and 20% less likely to be married [31].

Table 2. Principles of pediatric obesity prevention

Begin early—at least by 2 years of age, if not earlier
Benefit all children—even those at low risk of obesity
Have no deleterious effects
Involve the whole family—healthy home environments
Educate and involve parents, teachers, and older children as role models
Involve preschool centers in heart healthy nutrition/physical activity
Have a strong child health education component (behavioral orientation)
Include a "child healthy" diet (Heart Healthy) at home and at preschool
Include adequate daily physical activity (active play for 30 min/d)
Limit inactivity (television viewing time, etc.)
Be relatively inexpensive

Obesity Prevention Strategies

Childhood obesity prevention efforts are likely to be most effective when targeted simultaneously toward primordial, primary, and secondary targets of prevention in a multileveled approach with appropriately different goals: primordial prevention, aiming to prevent children from becoming at risk of overweight; primary prevention, aiming to prevent at-risk children from becoming overweight; and secondary prevention, aiming to prevent increasing severity of obesity and reduce comorbidity among overweight children [32]. Within this frame of reference, key priorities for action can be identified, prioritized, and linked to potentially successful intervention strategies. Because primordial and primary obesity prevention initiatives are most likely to be effective if begun before school age and sustained during childhood and adolescence, a significant effort should be directed toward obesity prevention efforts aimed at young children in the first decade of life. In addition, prevention of obesity in childhood will require both population and high-risk approaches to the problem (Table 2).

The most desirable prevention goal would be the primordial prevention of obesity (*ie*, preventing children with desirable BMI [less than 85th percentile] from becoming at-risk of overweight [85th to 94th percentile]). Success in achieving this goal is most likely to occur if prevention strategies and interventions are initiated in the first few years of life, perhaps even beginning during the prenatal period and infancy. There are several reasons for emphasizing primordial prevention, the most significant of which are related to adipocyte physiology, adiposity rebound, and the limited potential for reversing metabolic changes associated with obesity. During fetal life, babies begin to develop fat cells (adipocytes) at around 15 weeks of gestation [33]. Rapid increase in fat cell number and size, especially during the third trimester of pregnancy, results in an increase in body fat from about 5% to 15% [34]. Thus by term birth, about one sixth of the infants weight is fat (a 6-lb baby would have about 1 lb of fat). This translates into about 5 billion adipocytes, or 16% of the 30 billion found in adults.

During infancy, fat cells increase primarily in size rather than number. Between 2 and 14 years of age, there is little change in fat cell size in lean children, and only a small increase in fat cell number from ages 2 to 10 years [33-35]. Among obese children, however, fat cells continue to increase in size [36]. Eventually, this triggers an increase in fat cell number when adipocyte lipid content exceeds about 1 μg of lipid per cell [37,38]. During therapeutic weight loss, the rate at which new fat cells are formed (from pericapillary fibroblasts) slows down in obese children, but still continues at a rate that is greater than in lean children [39]. Thus, once obesity has developed in childhood, it may be restrained but perhaps not reversed, giving added impetus for primordial prevention.

There is also evidence that adverse prenatal influences that result in low rates of fetal growth may increase risk of later obesity, type II diabetes mellitus, and other cardiovascular disease (CVD) risk factors (*eg*, elevated BP, cholesterol, fibrinogen, and reduced arterial compliance) [40,41]. In a survey of 216 adolescent girls (aged 14 to 16 years), the girls who were smallest at birth but who were fattest at time of assessment were the most centrally obese. Among overweight girls with BMI greater than 25, the ratio of subscapular to triceps skinfold thickness rose by 27% for every kilogram decrease in birth weight [42]. In a large Finnish cohort study of 3659 men and women born from 1923 to 1933, the incidence of type II diabetes increased with decreasing birth weight, birth length, ponderal index, and placental weight, consistent with the hypothesis that type 2 diabetes is programmed in utero in association with low rates of fetal growth. The increased risk for type 2 diabetes associated with small size at birth was further increased by high growth rates after 7 years of age. Children whose mothers had a high BMI in pregnancy had more rapid growth during childhood and an increased

incidence of type 2 diabetes [41]. In the same cohort, however, incidence of obesity based on self-reported lifetime maximum BMI of greater than 30 was threefold higher if BMI at 7 years of age was above 16 (versus below 14.5). In addition, by 7 years of age, the mean weights, heights, and BMI of people who later became obese exceeded the average and remained above average at all ages from 7 to 15 years. The incidence of adult obesity rose with increasing birth weight and ponderal index; however, these associations were significant for men only [43].

Several studies suggest that promoting and supporting breast feeding may be an important component of childhood obesity prevention. Von Kries *et al*. [44] found a substantial, dose-dependent, protective effect of infant breast feeding on the prevalence of obesity and overweight in children. Specifically, 3 to 5 months of exclusive breast feeding was associated with a 35% reduction in obesity at 5 to 6 years of age. Dewey *et al*. [45] found that formula-fed infants were heavier than exclusively breast-fed babies during the first year of life, although length and head circumference were similar. In the same study, breast feeding mothers lost weight more effectively after pregnancy than those who fed artificially, which is important because parental obesity is such a strong risk factor for child obesity [46]. In a hospital chart audit, minimal or no breast feeding was positively associated with adolescent obesity in the lower, but not higher, socioeconomic status group. However, when gender, birth weight, and socioeconomic status were included in a multiple regression model, duration of breast-feeding was no longer significantly associated with obesity during adolescence [47].

Preschools and schools are also of critical importance in implementing effective obesity prevention programs for children and youth. Children spend a large proportion of their day in preschools and schools; they are educated and influenced by their teachers and peers; they usually eat lunch at school, and sometimes breakfast and snacks. The frequency, intensity, and duration of their physical activity are strongly influenced by the school's physical education, sports, and after-school programs. The presence of appropriately trained staff and the availability of adequate gyms, playgrounds, equipment, and educational resources are also critical. School policies can promote or discourage healthful diets and physical activity, especially policies regarding vending machines, a la carte menus, timing and length of lunch periods, policy regarding leaving the school campus for lunch, bussing, use of bicycles and cars, etc. [48].

Innovative educational programs designed to increase children's nutrition and health knowledge, as well as positively influence diet and physical activity and decrease inactivity, have been developed, implemented, and evaluated in pilot programs during the past decade. Healthy-Start (http://www.Healthy-Start.com), a preschool health education program, demonstrated increased nutrition and health knowledge among 2- to 5-year old children, decreased the saturated fat content of preschool meals and snacks, and reduced blood cholesterol levels of preschool children [49–51]. The Child and Adolescent Trial for Cardiovascular Health (CATCH), an elementary school–research initiative involving 5106 children in third through fifth grade in 96 schools, was successful in reducing total and saturated fat intake, as well as increasing the frequency and duration of moderately vigorous physical activity [52–56]. These changes were sustained by the intervention group when surveyed 3 years later; the first school-based intervention that has been able to demonstrate sustained beneficial effects without continued intervention [57]. Planet Health and other school programs aimed more specifically to decrease inactivity, as well as improve eating behavior and make healthier food choices, towards its goal of preventing obesity. Their results were encouraging in that they were able to decrease hours of television watched and other sedentary behaviors during the intervention, and this translated into beneficial effects on BMI in some, but not all, of the children [58,59]. In addition to these programs, other new school-based initiatives are currently in progress for children of all ages.

Diet and Childhood Obesity

The past four decades have witnessed enormous changes in the eating patterns and lifestyles of American children and their families. Many of these changes tend to favor an increase in energy intake and a reduction in energy expenditure, both of which favor the development of obesity. More than two thirds of mothers with children work outside of the home, and prefer the time-saving advantages of ready-made foods and take-out dinners. Typically, these meals are higher in energy, fat, saturated fat, and sodium than foods prepared from raw ingredients at home. Children now, compared with 30 years ago, consume more fast foods, pre-prepared meals, snacks, and caloric beverages other than milk. Data from NHANES III (1988 to 1994) indicates that American children on average consume 33% to 34% of their calories as fat, compared with the recommended level of 30% or less; and that saturated fat intake (at 12%) is still higher than recommended (less than 10%) [60••]. A recent summary of national survey data for American adolescents (1965 to 1996) revealed that 11- to 18-year-old children currently drink more low-fat milk than full-fat, but overall drink 36% less milk than in the 1960s (preferring more soft drinks and juice). Vegetable intake increased over the three decades, but this was due to greater consumption of higher-fat potatoes [61]. Beverages currently contribute 20% to 24% of energy for children and youth, and soft drinks provide 8% of energy intake in adolescents. Soft drink–energy intake is also higher among overweight than nonoverweight youth [60••]. Troiano *et al*. [60••] also reported that overall energy intake in children and adolescents has changed little in the past three decades based on the NHANES data, except for an increase in adolescent

females. In one 19-month prospective study of 548 sixth- and seventh-grade school children, both BMI and frequency of obesity increased for each additional serving of sugar-sweetened drink consumed, and baseline consumption of sugar-sweetened drinks was also independently associated with change in BMI over the 19-month period of time [62].

Snacking patterns of children (2 to 18 years of age) have also changed dramatically over the past two decades (1977 to 1996). More children snack now than before (90% vs 80%), with the greatest increase seen in the past decade. Average energy intake from snacks has increased from 450 to 600 calories per day, and now accounts for 25% of daily energy intake. In addition, the energy density of children's snacks has increased significantly from 1.35 to 1.54 kcal/g [63]. This finding is significant because research suggests that small increases in the energy density of foods consumed can lead to large increases in total energy intake. Thus, current snacking trends may be contributing to the increase in childhood obesity [63].

Parents exert a strong influence over the food intake of children, especially when they are young. In one study, however, the more often parents of young children encouraged them to eat certain foods, the less likely they were to do so [64]. In addition, for preschool girls (but not boys), the more their parents restricted certain "treats" at home, the more the child over-ate them when given the opportunity to do so in a research laboratory setting [65]. Thus, in early childhood, it is recommended that parents provide children with healthy, balanced, nutrient-adequate meals and snacks, and let children choose whether and how much of the healthy foods they will eat. In a school-based study of third grade children, however, parental control over children's food intake was inversely associated with overweight in girls (but not boys), with overweight measured by BMI and triceps skinfolds [66]. Thus, the relationship between parental behaviors and children's eating behaviors and weight gain may vary significantly in families with diverse socioeconomic and ethnic backgrounds, and with the age of the child.

Unfortunately, families now eat fewer meals together than ever, a regrettable trend because studies show that children who eat meals with their family consume more fruits and vegetables, less soda, and less fat in food both at home and away from home [67]. In addition, parents have limited control over the type and amount of food that children consume away from home. Because one fourth of calories are usually consumed at lunch (usually at school) and one third of calories consumed as snacks during the day, this means that almost 60% of the child's daily energy intake, 5 days per week, may be largely consumed away from home.

Preventing Obesity in Young Children

Fostering the delicate balance between energy intake and energy expenditure is becoming increasingly more difficult. The key strategies involve helping young children develop and maintain healthy dietary patterns, balanced by adequate daily physical activity. The Food Guide Pyramid for preschool children from the United States Department of Agriculture more clearly defines the number of servings of foods from each area of the pyramid that should be consumed by young children [68]. More importantly, it clarifies portion size for this age group, because in the past there had been confusion as to what constitutes a portion size for a young child. For most 2- to 6-year-old children, energy requirements, as well as macronutrient and micronutrient needs, will be met if over an average of 3 days they consume six servings of the grain groups, three servings of the vegetable group, two servings of the fruit group, two servings of the milk group, and two servings of the meat group. In general, 2- to 3-year-old children will consume fewer calories and smaller portions (about two-thirds regular size) than older children. By 4 years of age, regular-sized portions apply. The key features of healthy "food-pyramid eating" for preschool children are summarized in Table 3.

The United States Department of Agriculture (USDA) Food Guide Pyramid does not specify a recommended fat content for milk and cheese, or recommend lean versus fattier meats or grain products. Guidelines from the American Heart Association recommend a fat-modified diet after age 2 years of age [69]. The Academy of Pediatrics recommends that preschool children gradually adopt a fat-modified diet after 2 years of age that provides no more than 30% of energy from fat (and no less than 20%) by 5 years of age [70]. One of the easiest ways to achieve this goal is for healthy children over 2 years of age to consume low-fat dairy products, such as 1% low-fat milk. This strategy, coupled with adequate consumption of vegetables, fruits, and fiber-containing grain products, and limiting intake of added sugars and fats (the "tip" of the pyramid), will result in an energy-adequate, calorically balanced, and fat-controlled diet. In addition to fat-controlled, healthy eating for preschoolers, daily physical activity is essential (30 min/d of active play).

Physical Activity and Childhood Obesity

Physical inactivity is an independent risk factor for coronary heart disease, and has assumed increasing importance in pediatrics and public health because of its contribution to the development of obesity, and because of its association with abnormal plasma lipids, high BP, and hyperglycemia, each of which contributes to risk of coronary heart disease. In pediatric populations, therefore, it is not surprising that children who are more physically active have less body fat and fewer cardiovascular risk factors. Less physical activity appears to be a major contributor to the development of childhood obesity, and obese children are less physically active than nonobese children. In a cross-sectional study of 187 sixth grade students who wore

Table 3. Healthy dietary patterns for preschool children

A good estimate of a serving for a 2- to 3-year-old child is about one third of what counts as a regular Food Guide Pyramid serving.
Children 2 to 3 years of age need the same variety of foods as older children, but usually need fewer calories.
Younger children eat smaller portions than older children. They should be offered smaller servings and allowed to ask for more. This will satisfy their hunger and not waste food.
By the time children are 4 years old, they can eat amounts that count as regular Food Guide Pyramid servings eaten by older family members (*ie*, 1/2 cup fruit or vegetable, 1/4 cup juice, 1 slice of bread, 2–3 oz of cooked lean meat, poultry, or fish).
New foods should be offered in small "try me" portions (1–2 tbsp). Children may not begin to like a new food until they have tasted it many times and become familiar with it.
Eating a variety of foods every day is important for the whole family. Offer children a variety of foods from the 5 major food groups, and let them decide how much to eat.
2- to 6-year-old children need 2 servings from the milk group each day.
After 2 years of age, drinking low-fat (1% or skim) milk will help preschoolers achieve a heart healthy diet and avoid excessive intake of saturated fat.
Young children's appetites can vary widely from day to day, depending on growth rates, environmental factors, and energy expenditure in play.
As long as children have plenty of energy, are healthy, are growing well, and are eating a variety of foods, they are probably getting enough of the nutrients they need from the foods they eat.

accelerometers for 7 days, total daily counts and other indices of moderate and vigorous physical activity were significantly lower in obese compared with nonobese children. Obese children also had lower levels of physical activity self-efficacy, were involved in fewer community organizations promoting physically activity, and had fathers who were less physically active [71].

Despite the known benefits of physical activity in childhood, many youth are sedentary [72]. Decreased physical education during school hours, increased sedentary free-time activities such as watching television, playing video and computer games, and the the Internet, increased bussing of children to schools, and lack of safe play areas for children in urban and suburban areas all contribute to fewer opportunities for physical activity for children, and a greater risk of obesity.

One of the goals of Healthy People 2000 was to increase vigorous physical activity to at least three times a week for 20 minutes or more per occasion in at least 75% of children and adolescents [73]. Boys of all ages tended to meet this goal, but girls between 11 and 16 gradually decrease their level of physical activity level during adolescence, as demonstrated in several national surveys [74].

Surveys suggest that American children have become less physically active and more obese over recent decades. In the 1988 to 1994 NHANES-III national survey of 4062 8- to 16-year-old children, 26% of girls and 17% of boys had two or less bouts of vigorous physical activity each week, whereas 80% reported three or more bouts weekly. In the same NHANES III survey, 26% of youth surveyed watched 4 or more hours of television daily, whereas 67% watched at least 2 hours a day. Children who watched 4 or more hours of television per day had greater body fat ($P<0.001$) than those who watched less than 2 hours per day [74]. The prevalence of childhood obesity was lowest among children watching 1 or less hours of television a day, and highest among those watching 4 or more hours a day [75]. Similarly, in another study of more than 10,000 9- to 14-year old children in the United States who were surveyed a year apart in 1996 and 1997, larger increases in BMI were seen in girls who reported less physical activity, more time with television/videos/games, and higher caloric intake. Larger increases in BMI were seen in boys who reported more time with television/videos/games. Although the magnitude of these estimated effects was small, their cumulative effects, year after year during adolescence, would produce substantial gains in body weight. Thus, strategies to prevent excessive energy intake, decrease television/videos/games, and to increase physical activity would be promising as a means to prevent obesity [76].

Some have speculated that repeated exposure to food commercials on television may prompt children to increase food consumption, leading to weight gain [77]. Epstein *et al.* [78] hypothesize that watching television while eating meals and snacks may become conditioned cues for some children, so that even when not hungry, watching television will cue eating. And indeed, decreasing inactivity has been a recent popular strategy for both preventing and treating childhood obesity. Epstein *et al.* [79] reported that obese children who decreased the number of hours spent in inactivity each day were more successful with weight loss than children who retained their usual levels of inactivity. Gortmaker *et al.* [58] decreased inactivity in a school-based research initiative (Planet Health) with some effectiveness demonstrated for girls, but not for boys. Similarly, Robinson [59] was successful in reducing television-watching time in a school-based clinical trial that also reduced some indices of obesity. Thus, reducing inactivity and television watching within a positive context, while providing healthier alternatives and more opportunities for school, after-school, and leisure-time physical activity and sports, shows promise as an effective obesity prevention strategy. All of these programs, however, also focused on healthier diets and food choices as well, so that a combined nutrition/physical activity focus is desirable.

Recent Trends in the Treatment of Childhood Obesity

An ideal time for initial clinical evaluation of children's weight status and overall CVD risk profile is after the age of 2 years and preferably before entering school, at age 5 or 6 years. The preschool period is preferable because lifestyle habits contributing to development of risk factors are begun during these early years, especially habits related to diet and physical activity. In addition, habits of shorter duration should be easier to change than those of long duration; thus interventions aimed at younger children may be more likely to succeed. Finally, this is when young parents are eager for advice on child care and visits to the pediatrician for immunizations and check-ups are more frequent, providing opportunities for assessment and early intervention if needed.

Height and weight should be plotted on standard National Center for Health Statistics (NCHS) growth charts. Determination of the percentile zones for each measure and comparison of the height percentile with weight percentile will give the first indication if the child is overweight for height. A child whose weight is two or more percentile zones above height may be overweight for height (*eg*, a child whose height is in the 10th to 25th percentile and whose weight is in the 75th to 90th percentile for age and sex) [80].

Measurement of subcutaneous fat with skin-fold calipers will add valuable information to simple height and weight measures by helping the clinician to determine if the overweight child is also overfat. In cases of significant obesity, physical inspection is enough to answer this question; however, skin-fold measures are very helpful as baseline determinations and as follow-up measures in subsequent treatment [2]. The triceps skinfold is often used as a measure of peripheral obesity, whereas subscapular skinfold is often referred to as an index of central obesity

Body mass index provides a guideline based on weight and height to determine underweight or overweight status [81••,82–84]. BMI is not an exact measure of fatness because levels of fatness among children vary at a given BMI. This is true because BMI reflects frame size, leg length, and the amount of lean and fat tissue. However, even though BMI correlates less well with percent of body weight that is fat compared with other more direct measures of fat such as triceps skinfold thickness, the large measurement error associated with triceps skinfold measurements (especially at high levels of fatness) and the more readily available weight and height data make BMI a more useful tool for assessment of overweight as a proxy for obesity. BMI in children and adolescents compares well with laboratory measurements of body fat. Children and adolescents with a BMI-for-age above the 95th percentile are classified as overweight. BMI values above the 95th percentile, applied as a definition of overweight in children are consistent across age groups, and are predictive of morbidity.

The rationale for proposing a pediatric BMI classification for weight status is based on studies that indicate that BMI is related to health risks. Overweight children are likely to become overweight adults, with risk increasing with severity and duration of the problem. Sixty percent of youth with a BMI-for-age above the 95th percentile have at least one risk factor for CVD, and 20% have two or more CVD risk factors [23]. High blood pressure, abnormal blood lipid levels (elevated total cholesterol, LDL cholesterol, or triglycerides, and low HDL cholesterol), insulin resistance and type II diabetes mellitus are some of the CVD risk factors observed in overweight children and adolescents. Overweight children are also at increased risk of a wide range of other medical and psychologic problems.

For children in the United States, BMI increases rapidly during the first year of life, and then begins to decline, reaching its lowest value on average between 4 and 6 years of age. After reaching this nadir, BMI again begins a slow increase throughout the rest of childhood and adolescence. The upward shift of the BMI curve, after reaching the lowest point, has often been called "adiposity rebound." Studies suggest that children who begin their adiposity rebound at younger ages are at greater risk for being overweight as older adolescents and young adults [85–87].

The Center for Disease Control (CDC) has published two BMI-for-Age charts for children: one chart for boys, aged 2 to 20 years; and another chart for girls, aged 2 to 20 years. These charts may be downloaded from the CDC web site: http://www.cdc.gov/nccdphp/dnpa/bmi/bmi-for-age.htm. In addition, at the same site, a CDC Table for Calculated Body Mass index Values for Selected Heights and Weights for Ages 2 to 20 Years, may also be downloaded. Clinicians can avoid having to calculate BMI values by using the values provided in this extensive set of tables, which cover heights in children from 29 to 78 in, and weights from 18 to 250 lb.

If a child's BMI is above the 95th percentile for age and gender based on the CDC BMI-for-age charts, the child should be evaluated for the presence of comorbidities, including careful measurement of BP, and blood lipids. In children with acanthosis nigricans and/or a family history of type II diabetes in first- or second-degree relatives, a fasting blood glucose and blood insulin level may be indicated. Other laboratory tests may be indicated to rule out hypothyroidism or elevated liver enzymes. In addition, patterns of physical activity, diet, and cigarette smoking should be assessed for both child and family, because these lifestyles are commonly shared and affect recommendations for treatment [85].

The treatment goal is based on the age of the child, the degree of obesity, and the presence or absence of complications or comorbidities. Weight maintenance is recommended for 2- to 7-year-old children at risk for obesity (BMI between the 85th and 94th percentiles, age/gender specific); for 2- to 7-year-old children who are obese (BMI greater than 95th percentile) if complications are absent; and for children

Table 4. Recommendations for weight goals for children over 2 years of age with BMI at or above the age age- and gender-specific BMI percentile

Age, y	2–7	2–7	≥7	≥7	≥7
BMI, percentile	85th–95th	≥95th	85th–94th	85th-94th	≥95th
Complications*	Absent or mild	Absent	Absent	Present	Absent or present
Goal	Weight maintenance	Weight loss	Weight maintenance	Weight loss	Weight loss

*Complications include dyslipidemias, elevated blood pressure, hyperinsulinemia, orthopedic problems, psychologic problems, sleep apnea, obesity hypoventilation syndrome, orthopedic problems, pseudotumor cerebri, steatohepatitis, and focal segmental glomerular sclerosis.
BMI—body mass index.
Adapted from Barlow and Dietz [81••].

over 7 years of age who are at risk for obesity (BMI between 85th and 94th percentiles) if complications are absent. Weight loss is recommended for all obese children over 7 years of age who have a BMI greater than the 95th percentile (whether or not complications are present). Weight loss is also recommended for children over 7 years of age who are at risk of obesity (BMI between 85th to 94th percentile) if complications are present, and for 2- to 7-year-old children who are obese (BMI greater than 95th percentile) if complications are present (Table 4).

The amount of weight loss recommended and the schedule for weight-loss goals will vary depending on the severity of obesity and the nature and severity of the complications. Children with potentially life-threatening complications, such as sleep apnea or obesity hypoventilation syndrome, are candidates for more rapid weight loss. Limited research data is available, however, to suggest a safe rate at which children and adolescents may lose weight without deceleration of growth velocity. Complications of obesity in childhood include dyslipidemias, elevated BP, hyperinsulinemia, orthopedic problems, psychologic problems, sleep apnea, obesity hypoventilation syndrome, orthopedic problems, pseudotumor cerebri, hepatic steatosis, and focal segmental glomerular sclerosis. In general, the greater the severity of the obesity, and the greater the number and severity of the complications, the more likely the child will need evaluation and treatment in a pediatric obesity center [81••].

Modifying Physical Activity Behaviors in the Treatment of Childhood Obesity

Most children need to increase their level of daily physical activity. Other health benefits of regular physical activity in childhood include increased levels of HDL cholesterol, lowered BP and resting heart rate, and improved physical appearance and self-esteem. All children over 2 years of age should get at least 30 minutes of moderately vigorous activity each day (a level that makes most children sweat). Obese children should be encouraged to engage in at least 30 minutes a day to start with, and gradually increase to 45 or 60 minutes daily. Charts may be provided so that children can choose their activities and monitor their progress, and appropriate rewards for this behavior can be negotiated to reinforce compliance with a "contract." With severely overweight children, physical activity will need to be increased gradually and be tailored to the child's physical ability in order to avoid failure and discouragement. Orthopedic problems may also limit the type of activities prescribed, and innovative solutions may be required.

Children generally participate in physical activity and sports when they are "having fun" and stop participating when they lose interest and feel they are no longer having fun. In treating obesity, it's important to determine what type of activities the child enjoys doing, and then develop a plan for incorporating these activities into the child's daily schedule. Children can be encouraged to choose one team sport or dance/gymnastics class each season (in addition to school gym, recess, and after-school play). Parents should be encouraged to facilitate their child's physical activity, be a good role model by increasing their own activity, and plan family activities with this goal in mind.

Treatment programs that have involved overweight children and adolescents in rigorous physical activity and fitness training have demonstrated significant benefit in achieving weight loss and improving fitness. In one 4-month controlled trial, 74 obese 7- to 11-year-old children were randomly assigned to either a 5-days per week, 40-minutes per session physical training program (without dietary intervention) or a control group. After the 4-month intervention, the treatment group declined significantly in percent body fat, total fat mass, and subcutaneous abdominal adipose tissue. They also increased fat-free mass and moderate-to-hard physical activity, and had less of an increase in visceral abdominal fat than the control group [88].

At the same time, efforts to decrease inactivity (television/videos/computer games and Internet time) are likely to produce an additive effect, because television viewing hours in children are positively correlated with obesity [74,75]. In one pilot study, the investigators studied the effects of "contingent television viewing" on physical activity and television viewing in 10 obese children. Television viewing was contingent on pedaling a stationary cycle ergometer for experimental participants, but not for control participants. Television watching in the experimental group during treatment was only 1.6 hours per week, compared with 21 hours for the control group. In addition, children in the experimental condition showed significantly greater reductions in

total body fat and percent leg fat. Total pedaling time during intervention correlated with greater reductions in percent body fat [89•].

Dietary Strategies in the Treatment of Childhood Obesity

It is helpful in the treatment of childhood obesity to evaluate the child's diet by means of a simple food frequency questionnaire, or with a 1-day or 3-day food diary. They provide a useful base for making recommendations for dietary change over time and help target areas most in need of change (*eg*, large portions, frequent fast-food meals, constant snacking, excess liquid calories, etc.).

Both weight-maintenance and weight-loss goals in children will require dietary modifications and often changes in eating patterns. For obese children more than 2 years of age, the first step in treatment is to help them follow the Academy of Pediatrics recommended balanced diet that specifies percentages from the major macronutrients that reflect the USDA Food Guide Pyramid Guidelines with respect to variety and portion size. This diet is then further modified to reduce caloric intake in children for whom weight maintenance or weight loss is desired, the latter requiring a greater reduction in energy intake. Sodium intake may be reduced if the child's BP is elevated. Dietary fiber intake is increased to heighten satiety and reduce constipation (nonviscous fiber, such as wheat bran) and serum cholesterol (viscous fiber, such as that found in oat bran, fruit pectins, guar gum, and psyllium).

A reasonable goal is to have the child lose 1 lb/wk (4 lb/mo) until the first goal is reached. To lose 1 lb, 3500 kcal must be eliminated through a combination of decreased caloric intake (diet) and increased caloric expenditure (exercise). The average 9- to 10-year-old child consumes about 2000 kcal/day; thus prescribing a 1500 kcal diet should result in a 1 lb/wk weight loss because this represents a 500 kcal/d decrease.

Older teens (especially boys) who have been consuming as much as 3000 kcal/d may have to be brought down gradually to 2500, then 2000, and perhaps even 1500 kcal/d depending on motivation and desire for rapidity of weight loss. Conversely, children under 10 years of age may need fewer than 1500 calories daily to lose weight. Implementation of the diet requires an understanding of portion size and allowable food exchanges and is most effective when this counseling is provided with the help of a registered dietician. Lists of exchanges can be provided to parents and children, along with the number of exchanges recommended for each food group. An advantage to using this system is that many of the parents will have used it previously if they belonged to a dieting group (*eg*, Weigh Watchers). Successful implementation of the diet also requires application of behavior-modification strategies and parental support.

Not all excess weight in children is fat, however, with up to 50% of excess weight being fat-free mass in some obese individuals. Obese children on the average have increased lean body mass (muscle and bone needed to support the excess weight) and increased basal metabolic rate (BMR) compared with lean children, and may need increased protein intake during caloric restriction to avoid negative nitrogen balance and loss of lean body mass.

Although it is theoretically possible to achieve weight loss with reduced calorie intake alone, there are compelling reasons for combining caloric reduction with increased caloric expenditure through physical activity. Indeed, the most successful weight-reduction programs appear to be those that combine diet with exercise within a matrix of behavior modification. The more calories expended, the less restrictive the diet must be to lose 1 lb/wk. The goal of eliminating 500 calories per day can be achieved through any combination of reduced caloric intake and increased physical activity (the "design-it-yourself" diet). Children may be able to lose weight with exercise alone if compensatory caloric increase does not occur.

The best rationale for combining diet and exercise is based on consideration of metabolic aspects of dieting. Caloric restriction often results in a drop in BMR, making it harder to lose weight. In addition, caloric restriction may result in a loss of lean body mass (as much as 37% of weight lost may be lean body mass). This can be avoided by increasing physical activity, which increases BMR and lean body mass. BMR often remains elevated for several hours after vigorous exercise. Therefore, effective weight reduction is most likely to occur when a combination of diet and exercise is recommended.

Short-term and Long-term Effectiveness of Pediatric Weight-control Programs

Fewer studies have been conducted on weight control in childhood and adolescence compared with studies in adults. Many of the studies that have been conducted in the past are summarized in a review [90•]. One of the difficulties in assessing outcomes in a clinical setting is that there is such a broad range in levels of motivation by both child and parents; there are vastly differing goals for treatment depending on the age of the child, the severity of the problem, and the presence or absence of comorbidities. And finally, in clinical practice, insurance companies and managed care often preclude implementation of an adequate treatment program, or sometimes refuse coverage for any treatment of childhood obesity at all.

There have been some controlled research studies of obesity treatment in children and youth. Epstein *et al*. [91] was able to demonstrate sustained benefit in a 10-year follow-up study. In this study, behavior modification, exercise prescription, and dietary guidelines (the "traffic light" diet of allowed and discouraged foods) provided the necessary tools for weight control. Although children were still overweight after active intervention, the degree of overweight was significantly reduced.

The type of diet that is both safe and effective for weight maintenance and weight loss in childhood has been explored in several studies. Most pediatric obesity treatment centers favor a balanced, calorie-controlled diet that provides adequate energy, macronutrients, and micronutrients for health [81••,90•,92]. In a treatment study of 107 obese but otherwise healthy children, those on a low-glycemic index diet for 4 months decreased body weight and BMI more than children on a traditional reduced-fat diet, and a greater proportion of children on the low-glycemic index diet reduced BMI by 3 kg/m^2 or more [93]. Other investigators have reported significant weight loss in obese preadolescent children following a 10-week medically supervised, very-low calorie, protein-sparing modified fast in addition to a moderately intense resistance-training program. Weight, percent body fat, percent ideal body weight, and BMI were reduced significantly at 10 weeks and did not increase significantly at 1 year of follow-up. Height and lean body mass increased significantly at 1 year [94].

The demonstrated short-term health benefits of successful weight reduction in childhood include improved lipid profiles, decreased fasting hyperinsulinemia, improved glucose tolerance, reduced blood pressure, and lower resting heart rates [81••]. Among obese boys, weight loss is also associated with increased testosterone and decreased estradiol hormone levels [95]. Whether or not these benefits are sustained over longer periods of time is unknown.

Conclusions

Childhood obesity is an increasingly prevalent chronic disease affecting the pediatric population that is associated with a significant number of immediate and future adverse health conditions. Prevention of childhood obesity requires both a population-based and high-risk approach, beginning prenatally with optimal nutrition. Treatment of childhood obesity in clinical practice depends on the age of the child, the severity of the obesity, and the presence or absence of complications. Weight-maintenance or weight-loss may be indicated as a desired treatment goal. Progress has been made in the past several years with respect to further elucidating the epidemiology and etiology of this disease, and in formulating strategies and guidelines for both effective prevention and treatment.

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