JAMA | Review

Obesity in Adolescents
A Review

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IMPORTANCE Obesity affects approximately 21% of US adolescents and is associated with insulin resistance, hypertension, dyslipidemia, sleep disorders, depression, and musculoskeletal problems. Obesity during adolescence has also been associated with an increased risk of mortality from cardiovascular disease and type 2 diabetes in adulthood.

OBSERVATIONS Obesity in adolescents aged 12 to younger than 18 years is commonly defined as a body mass index (BMI) at the 95th or greater age- and sex-adjusted percentile. Comprehensive treatment in adolescents includes lifestyle modification therapy, pharmacotherapy, and metabolic and bariatric surgery. Lifestyle modification therapy, which includes dietary, physical activity, and behavioral counseling, is first-line treatment; as monotherapy, lifestyle modification requires more than 26 contact hours over 1 year to elicit approximately 3% mean BMI reduction. Newer antiobesity medications, such as liraglutide, semaglutide, and phentermine/topiramate, in combination with lifestyle modification therapy, can reduce mean BMI by approximately 5% to 17% at 1 year of treatment. Adverse effects vary, but severe adverse events from these newer antiobesity medications are rare. Surgery (Roux-en-Y gastric bypass and vertical sleeve gastrectomy) for severe adolescent obesity (BMI ≥120% of the 95th percentile) reduces mean BMI by approximately 30% at 1 year. Minor and major perioperative complications, such as reoperation and hospital readmission for dehydration, are experienced by approximately 15% and 8% of patients, respectively. Determining the long-term durability of all obesity treatments warrants future research.

CONCLUSIONS AND RELEVANCE The prevalence of adolescent obesity is approximately 21% in the US. Treatment options for adolescents with obesity include lifestyle modification therapy, pharmacotherapy, and metabolic and bariatric surgery. Intensive lifestyle modification therapy reduces BMI by approximately 3% while pharmacotherapy added to lifestyle modification therapy can attain BMI reductions ranging from 5% to 17%. Surgery is the most effective intervention for adolescents with severe obesity and has been shown to achieve BMI reduction of approximately 30%.

JAMA. doi:10.1001/jama.2024.11809
Published online August 5, 2024.

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Section Editor: Kristin Walter, MD, Deputy Editor.

Obesity is a disease characterized by excess body fat that impairs health.[1] A body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) at the 95th percentile or greater for age and sex based on standardized growth curves is often used as a clinical screening tool to identify adolescents who may benefit from treatment.[2] The prevalence of obesity in adolescents aged 12 to younger than 18 years old in the US is approximately 21%.[3,4] Obesity in adolescence strongly predicts obesity in adulthood.[5] Treatments for adolescent obesity include lifestyle modification therapy, pharmacotherapy, and metabolic and bariatric surgery (the prior terminology for surgery, including *weight loss surgery* and *bariatric surgery*, has been replaced by the term *metabolic and bariatric surgery* to acknowledge the mechanisms of action of the surgical procedures). The approach to treating obesity differs for adolescents compared with younger children or adults due to unique factors such as pubertal development and psychosocial maturation including the emergence of autonomy and independence. Advances in adolescent obesity treatments include US Food and Drug Administration (FDA) approval of 3 antiobesity medications since 2020.[6-8] The American Academy of Pediatrics (AAP) published a Clinical Practice Guideline for the Evaluation and Treatment of Children and Adolescents With Obesity in 2023,[2] which highlighted new themes regarding the approach to management of obesity in adolescents (**Box 1**). This Review summarizes the current evidence regarding the epidemiology, pathophysiology, diagnosis, and treatment of adolescent obesity.

Methods

We searched PubMed for English-language articles published from January 1, 2013, to April 1, 2024, including epidemiological, longitudinal, and cross-sectional studies, as well as randomized clinical trials,

Box 1. Contemporary Views of Adolescent Obesity From the American Academy of Pediatrics Clinical Practice Guideline for the Evaluation and Treatment of Children and Adolescents With Obesity in 2023

Parents and teenagers should not be blamed. Weight bias and stigma result from lack of understanding of the underlying pathophysiology of obesity and lead to worse health outcomes.

Adolescent obesity is a chronic, progressive, and relapsing disease.

The etiology of adolescent obesity is complex and multifactorial, including environmental, genetic, and psychosocial drivers.

Obesity tracks strongly from adolescence to adulthood. "Watchful waiting" is no longer appropriate; treatment should be offered immediately on diagnosis.

Treatment of adolescent obesity should be initiated as intensively as possible; the entire spectrum of options should be considered.

Intensive health behavior and lifestyle therapy is required to attain meaningful weight reduction.

Multiple safe and effective antiobesity medications are available for adolescents.

Evidence supports the safety and long-term effectiveness of metabolic and bariatric surgery in adolescents with severe obesity.

comparative effectiveness studies, systematic reviews, meta-analyses, narrative reviews, and clinical practice guidelines related to adolescent obesity. Additional studies were identified by reviewing reference lists from relevant articles. A total of 92 articles were selected for this review, consisting of 6 randomized clinical trials; 11 meta-analyses and systematic reviews; 38 epidemiological, longitudinal, population-based, and cross-sectional studies; 7 clinical practice guidelines; 9 policy guidelines; and 21 narrative reviews. Included articles were reviewed by the authors for quality and relevance to a general medical audience and were prioritized based on recent advances in the field. This review focuses on management of obesity; topics such as prevention of adolescent obesity were deemed beyond the scope of this review.

Discussion

Epidemiology

The prevalence of obesity in US adolescents aged 12 to younger than 18 years increased from 16.0% during 1999-2002 to 20.9% during 2015-2018.[3,4] During this time, the prevalence of severe obesity, defined as a BMI of 120% or greater of the 95th percentile or BMI of 35 or greater[2,9] increased from 5.3% to 7.6% among US adolescents.[3,4] Obesity prevalence in the US differs by race and ethnicity, with higher prevalence in non-Hispanic Black (28%) and Mexican American (31%) adolescents as compared with non-Hispanic White adolescents (16%).[4] Evidence suggests that social and environmental factors, such as racism, trauma, poverty, and weight stigma, may be associated with a higher prevalence of obesity.[10-13]

Risk Factors

Risk factors for obesity in adolescence include genetic, environmental, lifestyle, and social influences. Genetic risk is a major contributor; twin studies have estimated the heritability of obesity to be between 40% and 70%.[14] Polygenic (or "common") obesity is associated with hundreds of polymorphisms; advances in genomic sequencing have identified more than 750 loci that collectively account for 6% of BMI variation.[14] Current obesity in 1 or both parents correlates modestly with obesity by age 15 years (Pearson $r = 0.29$, $P < .001$),[15] which likely reflects both genetic and environmental risk.

Several lifestyle behaviors and family structural factors are also associated with obesity in adolescents. Adolescents who spend 2 hours or more per day in recreational screen time have an increased risk (odds ratio, 1.67 [95% CI, 1.48-1.88]) of overweight or obesity (absolute rates not reported).[16] Short sleep duration is also associated with higher BMI; in a systematic review and dose-response meta-analysis of prospective cohort studies of children and adolescents, for every 1 hour per day additional increment in sleep duration, the risk of overweight or obesity decreased by 21% (odds ratio, 0.79 [95% CI, 0.7-0.89]).[17]

Poverty is a risk factor for adolescent obesity; children who experienced poverty before age 2 years were 2.3 times more likely to have obesity at age 15.5 years (absolute rates not reported).[18] Factors that explain this association include high availability and low cost of fast food and sugar-sweetened beverages, low neighborhood walkability, and household circumstances (eg, parental divorce, substance use) that cause stress and poor sleep.[2] Food insecurity, defined as inadequate access to food or resources to purchase food, is also associated with a higher prevalence ratio (1.3 [95% CI, 1.2-1.5]) of obesity among adolescents, with a 25.9% prevalence in food insecure vs 19.5% prevalence in food secure participants, although this association was not significant when controlling for race, ethnicity, and income.[19] Adverse childhood experiences, such as physical abuse, sexual abuse, or incarceration of a parent, also contribute to obesity risk. The accumulation of 4 or more adverse childhood experiences was associated with a 1.4- to 1.6-fold increase in risk for severe obesity in young adulthood (absolute rates not reported).[20]

Pathophysiology

Obesity results from an imbalance between energy intake and expenditure leading to accumulation of excess body fat. Function-altering gene variants, such as *TMEM18*, have been identified, which regulate hunger, satiety, and energy.[21] The pathophysiology of obesity is characterized by dysregulated metabolism favoring positive energy balance, intake that exceeds expenditure. Hormones such as ghrelin, leptin, peptide YY, gastric inhibitory polypeptide, glucagon-like peptide 1 (GLP-1), pancreatic polypeptide, amylin, and cholecystokinin increase weight gain by influencing appetite, satiety, and food palatability.[22-24] Targeting the physiological processes promoting body fat storage, such as appetite, satiety, and cravings, may be an essential component of effective obesity management.

Clinical Presentation, Assessment, and Diagnosis

The AAP recommends clinicians screen all adolescents for overweight and obesity using BMI as part of the annual well-child visit.[2] In 2022, the US Centers for Disease Control and Prevention (CDC) released obesity-specific pediatric growth curves with updated BMI reference data through 2016 (https://www.cdc.gov/growthcharts/extended-bmi.htm). A BMI at or above the 85th percentile to less than the 95th percentile for age and sex is defined as overweight, BMI at or above the 95th percentile to less than 120% of the 95th percentile for age and sex is defined as class 1 obesity, BMI at

or above 120% of the 95th percentile (or BMI ≥35, whichever is lower) to less than 140% of the 95th percentile for age and sex is defined as class 2 severe obesity, and BMI at or above 140% of the 95th percentile for age and sex (or BMI ≥40, whichever is lower) is defined as class 3 severe obesity.[2] Recent criticisms of using BMI to guide obesity management include that it is unable to distinguish between fat and fat-free mass, thus, is only an estimate of adiposity. While not a direct measure of adiposity, BMI is validated in diverse US adolescents, is age- and sex-normed, and has moderate sensitivity (70%-80%) and high specificity (95%) for excess adiposity compared with reference standard dual-energy radiograph absorptiometry.[25] BMI is also important in guiding additional screening for comorbidities. During adolescence, obesity is associated with hypertension, metabolic dysfunction–associated steatotic liver disease, dyslipidemia, sleep disorders, musculoskeletal problems, depression, anxiety, and eating disorders.[2] Compared with adolescents with overweight, those with severe obesity have a higher prevalence of high total cholesterol level (10.8% vs 19.4%, $P = .008$), low high-density lipoprotein cholesterol level (7.8% vs 23%, $P < .001$), high triglyceride level (12.2% vs 29%, $P = .002$), high systolic and diastolic blood pressure (0.3% vs 3.8%, $P < .001$), and high glycated hemoglobin level (15.6% vs 24.3%, $P = .003$).[26] The US Preventive Services Task Force (USPSTF)[27] and the AAP recommend clinicians use CDC sex- and age-specific BMI growth curves to screen for obesity from ages 2 to 18 years.[28] Before engaging in discussions about obesity, clinicians should seek permission to address the topic and assess the adolescent's preferences for discussing weight and BMI to reduce stigma and improve the therapeutic relationship.[29]

The Institute for Healthy Childhood Weight, affiliated with the AAP, provides a 1-page algorithm summarizing the evaluation of adolescents diagnosed with overweight or obesity (https://www.aap.org/en/patient-care/institute-for-healthy-childhood-weight/). This algorithm includes standard components of the adolescent annual visit (ie, a comprehensive history, physical examination, and blood pressure) as well as obesity-specific recommendations based on risk. For example, adolescents with obesity have a higher risk of depression than healthy weight peers (relative risk, 1.32 [95% CI, 1.09-1.60]) (absolute rates not reported)[30]; thus, clinicians should screen adolescents with overweight and obesity for depression, using a validated screening tool such as the Patient Health Questionnaire 9.[31] The presence of snoring on review of systems suggests possible sleep apnea, and although there are no questionnaires or physical examination findings that predict sleep apnea, it is present in up to 60% of adolescents with obesity.[32] The prevalence of hypertension is higher in adolescents with obesity and overweight (31.4% and 18.2%, respectively) as compared with healthy weight peers (11.9%, $P < .001$).[33] Annual laboratory testing for adolescents with obesity includes screening for type 2 diabetes (hemoglobin A_{1c}, fasting glucose, or oral glucose tolerance test), metabolic dysfunction–associated steatotic liver disease (alanine aminotransferase), and cholesterol (fasting lipid panel).[2] The full evaluation recommendations are included in the algorithm referenced above and summarized in **Table 1**.[2,31,34-40]

Obesity Care and Treatment Options

The Obesity CARE continuum includes classification of severity, assessment of risk, respect for autonomy, and engagement in treatment (**Figure**). Evidence-based obesity treatment includes lifestyle modification, pharmacotherapy, and metabolic and bariatric surgery (**Table 2**).[2,8,28,41-44] A stepped approach to care is no longer recommended; obesity becomes more severe and comorbidities accumulate over the adolescent years. Thus, adolescents should be offered obesity treatment at the time of diagnosis, and all medically indicated treatment options should be discussed with the patient and caregivers using shared decision-making to create a treatment plan.[2] **Box 2** addresses questions commonly asked by clinicians regarding adolescent obesity care.[2,45,46]

Lifestyle Modification Therapy

Lifestyle modification refers to changes in nutrition, physical activity, sleep, or other daily habits that are obesity risk factors to reduce BMI and improve overall health. Lifestyle modification can be individual, group-based, commercial (eg, WeightWatchers), community-based (eg, YMCA), or supported by the health care system.

The systematic evidence review[47] underlying the 2023 AAP Clinical Practice Guideline did not identify high-quality evidence for recommending specific health behaviors as a stand-alone strategy to reduce BMI. However, many lifestyle recommendations have overall health benefit and are endorsed by professional organizations. These lifestyle recommendations include reducing sugar-sweetened beverages,[48,49] engaging in 60 minutes of moderate to vigorous physical activity daily,[50,51] and limiting social media use and overall screen time, although without specifying an upper limit of use.[52]

Motivational interviewing, a collaborative, person-centered form of communication, aims to elicit and strengthen motivation for behavior change. It can be delivered by various members of the health care team[53] and is commonly included as a component of comprehensive lifestyle modification therapy[2] because it supports patient preferences and autonomy, reduces patient perceptions of clinician weight bias, and decreases clinician burnout.[54] However, systematic reviews and meta-analyses have demonstrated a lack of effect of motivational interviewing alone in reducing BMI in adolescents with obesity.[55,56]

More intensive forms of lifestyle modification are an important component of obesity treatment in adolescents. The USPSTF (updated in June 2024)[41] and CDC, which conducted systematic reviews informing the 2023 AAP Clinical Practice Guideline,[27,28,47] both reported that longitudinal care is required to observe effectiveness; "longitudinal" was defined as the number of contact hours over up to 12 months. Overall, 35% of the studies demonstrated a decrease in BMI, including 25% of studies with low-intensity interventions (<5 contact hours), 35% of studies with moderate-intensity interventions (5-25 contact hours), and 71% of studies with high-intensity interventions (26-51 contact hours). The magnitude of treatment effect on BMI reduction was modest, with the greatest BMI changes (3% to 5%) observed in high-intensity interventions delivered over at least 3 to 12 months. The most effective interventions included nutrition and physical activity components and peer support groups, and were delivered in person.[47] While these pooled results included studies of children, the largest reduction in BMI occurred in adolescents.[47] Lifestyle treatment appears to be least effective for adolescents with the most severe forms of obesity,[57] suggesting this group may benefit from medical or surgical treatment. All studies observed a significant heterogeneity in treatment response, which is common across all obesity treatments.[58]

Table 1. Obesity-Related Comorbidities and Complications and Their Signs, Symptoms, Risk Factors, and Screening Tests

Comorbidity/complication	Signs and symptoms	Risk factors	Screening test(s)
Metabolic			
Diabetes	Polyuria, polydipsia, unexpected weight loss, fatigue, new-onset enuresis; acanthosis nigricans, skin tags	Family history, maternal gestational diabetes, polycystic ovary syndrome, hypertension, dyslipidemia, metabolic dysfunction–associated steatotic liver disease, small for gestational age	≥10 y old: fasting plasma glucose (≥126 mg/dL), 2-h oral glucose tolerance test (≥200 mg/dL), or glycated hemoglobin (hemoglobin A_{1c}) (≥6.5%)[34]
Metabolic dysfunction–associated steatotic liver disease (formerly nonalcoholic fatty liver disease)	Often asymptomatic; jaundice in severe cases; hepatomegaly	Male sex, Hispanic or Asian race and ethnicity, obstructive sleep apnea, diabetes/prediabetes, dyslipidemia	≥10 y old: alanine aminotransferase (ALT); exclude other causes of transaminitis if ALT ≥2 × upper limit of normal or ALT ≥52 IU/L for males and ALT ≥44 IU/L for females for ≥3 mo, or ALT >80 IU/L[35]
Dyslipidemia	Often asymptomatic; xanthoma or xanthelasma with familial hypercholesterolemia	Family history of cardiovascular disease, diabetes, hypertension, cigarette smoking	≥10 y old: fasting lipid profile, including total (≥170 mg/dL), low-density lipoprotein (≥110 mg/dL), and high-density lipoprotein (<45 mg/dL) cholesterol levels, and triglyceride level (≥90 mg/dL)[36]
Hypertension	Often asymptomatic, headache, blurry vision, dizziness, nosebleeds with severely elevated blood pressure	Family history	Blood pressure ≥95th percentile (ages 1-12 y) or ≥130/80 mm Hg (ages ≥13 y)
Polycystic ovary syndrome	Acne, hirsutism, alopecia, oligoamenorrhea or amenorrhea	Family history, insulin resistance	Total testosterone, free testosterone, sex hormone–binding globulin; to rule out other causes of hyperandrogenism and ovarian dysfunction: 17-hydroxyprogesterone, dehydroepiandrosterone sulfate, androstenedione, luteinizing hormone, follicle-stimulating hormone, estradiol, prolactin, free thyroxine, thyroid-stimulating hormone, pregnancy test[37]
Nonmetabolic			
Depression	Irritability, fatigue, insomnia, excessive sleeping, decline in academic performance, flat affect	Family history, bullying	Patient Health Questionnaire 9[31]
Obstructive sleep apnea	Snoring, apnea, fatigue, nocturnal enuresis, difficulty focusing/concentrating	Family history, adenotonsillar hypertrophy, allergic rhinitis	Polysomnogram with at least 1 symptom[2]
Idiopathic intracranial hypertension	Headache, nausea, vomiting, vision loss, diplopia, tinnitus, papilledema		Ophthalmological examination[38]
Slipped capital femoral epiphysis	Hip, groin, thigh, or knee pain; limp		Bilateral hip x-ray[39]
Blount disease	Painful genu varus (bow-legged) deformity		Leg x-ray[40]

SI conversion factors: To convert alanine aminotransferase to µkat/L, multiply by 0.0167; cholesterol to mmol/L, multiply by 0.259; glucose to mmol/L, multiply by 0.0555; and triglyceride to mmol/L, multiply by 0.0113.

Although lifestyle modification does not result in the largest BMI reduction as compared with other treatment options, it is recommended for all adolescents with obesity. However, lifestyle treatment programs that meet high-intensity criteria are not widely accessible.[59] Clinic-community partnerships, where clinicians screen for obesity and treat comorbidities and community partners provide space, staffing, and convenient locations, may address access barriers to exercise and nutrition programs. These partnerships (eg, YMCA, municipal parks and recreation) have potential to improve implementation, effectiveness, and sustainability of intensive health behavior and lifestyle treatment for adolescent obesity.[60,61]

Stigmatization of adolescents with obesity is common, occurs across multiple settings (ie, school, home, health care, sports), and may result in binge eating behaviors, social isolation, and avoidance of health care.[62] Adolescence is a critical developmental period, and teenagers are currently influenced by social media, which idealizes thinner bodies and whose use is associated with high levels of body dissatisfaction.[63] Eating disorders, in particular binge eating disorder, are more common in adolescents with obesity compared with healthy weight peers (9.3% vs 2.1% in males; 20.2% vs 8.4% in females).[64] A 2019 systematic review with 2589 participants reported that evidence-based lifestyle modification therapy in the context of residential camps, community programs, hospital settings, and other supervised individual or group programs decreased the risk for disordered eating.[65]

Pharmacotherapy

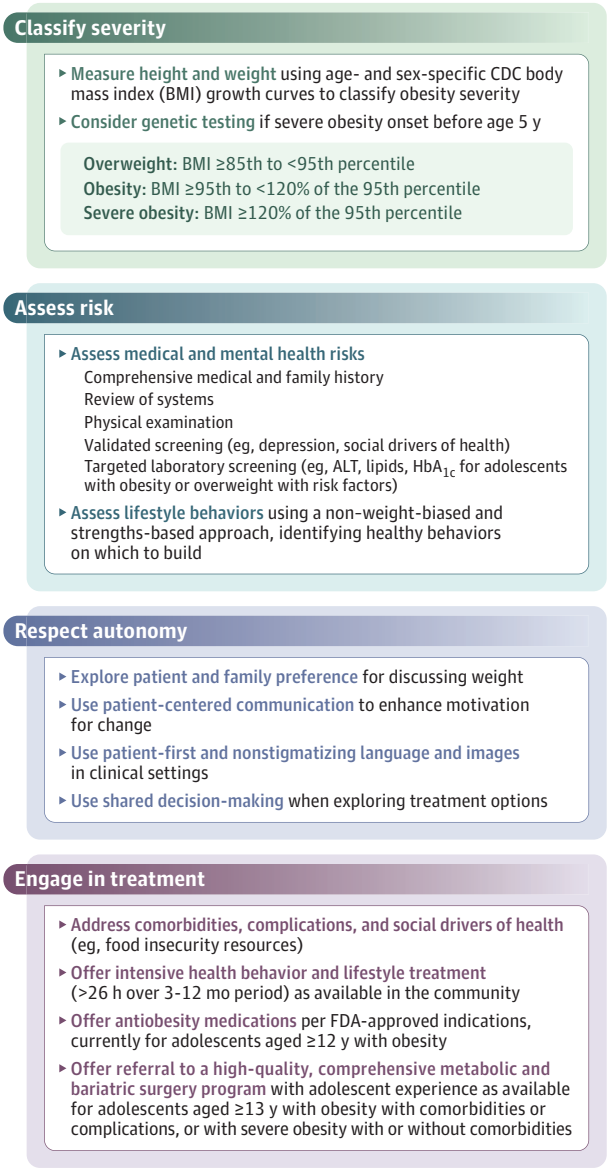
Prior to 2020, orlistat was the only FDA-approved medication for chronic treatment of obesity in adolescents. After 2020, several randomized clinical trials examining the safety and efficacy of antiobesity medications in adolescents have been published (**Table 3**).[6-8,42] These studies examined liraglutide,[6] phentermine/topiramate,[7] semaglutide,[8] and setmelanotide for patients with specific types of monogenic obesity and syndromic obesity. While the AAP Clinical Practice Guideline did not include all of these pharmacotherapy trials in their recommendations due to the timing of the evidence review, it provided guidance that pediatric clinicians "should" offer FDA-approved antiobesity medications to adolescents with obesity aged 12 years or older according to medication indications and risks.[2] The AAP recommended antiobesity medications be used with the most intensive lifestyle modification therapy available and should not be withheld if the recommended 26 hours or more of lifestyle therapy is not available. All clinical trials to date have included lifestyle modification therapy; there is no evidence supporting antiobesity medications used as monotherapy.

GLP-1 Receptor Agonists (Liraglutide and Semaglutide)

Liraglutide was FDA approved in 2020 for adolescents with obesity aged 12 years and older. Liraglutide is a short-acting GLP-1 receptor agonist (GLP-1 RA) developed to treat type 2 diabetes and is FDA approved for this indication in children aged 10 years and older.[66] In addition to its glycemic mechanisms of action, GLP-1 RAs act on the hypothalamus to suppress appetite, enhance satiety centrally (hind brain) and peripherally (potentially slowing gastric emptying), and may also act on reward pathways in the brain.[67,68] The obesity treatment dose of liraglutide, 3 mg, daily subcutaneous injection was evaluated in a 56-week randomized clinical trial of 251 adolescents with obesity aged 12 to 18 years.[6] The treatment phase was followed by a 26-week follow-up period in which liraglutide/placebo was withdrawn. In the treatment phase, the mean placebo-subtracted difference in change in BMI was −4.64% (95% CI, −7.14% to −2.14%). At 56 weeks, 43.3% vs 18.7% of participants achieved a 5% or greater BMI reduction in the liraglutide vs placebo group and 26.1% vs 8.1% achieved a 10% or greater BMI reduction. During the follow-up period (from week 56-82), both groups experienced an increase in the BMI standard deviation score (0.22 vs 0.07 with liraglutide vs placebo, respectively).

Semaglutide, 2.4 mg, another GLP-1 RA, was approved by the FDA in 2022 for obesity in adolescents aged 12 years and older. Semaglutide has a longer half-life than liraglutide, enabling weekly dosing. A randomized clinical trial of semaglutide vs placebo in 201 participants aged 12 to 18 years reported a mean placebo-subtracted

Figure. Adolescent Obesity CARE Framework



BMI is calculated as weight in kilograms divided by height in meters squared. ALT indicates alanine aminotransferase; CDC, Centers for Disease Control and Prevention; FDA, Food and Drug Administration; and HbA_{1c}, hemoglobin A_{1c}.

Table 2. Components of Comprehensive, Evidence-Based Obesity Care for Adolescents

Approach	Eligible patients	Description or examples	Mean BMI reduction	Other considerations
Intensive health behavior and lifestyle treatment[2]	BMI ≥85th percentile	Involves frequent contact (≥26 h) over a period of 3-12 mo between the patient/family and a multidisciplinary treatment team including clinicians trained in lifestyle-related fields[2] Interactions can be individual, group-based, or both; face to face has strongest evidence with some evidence supporting virtual[2] Consists of health education and skill building, along with behavior modification and counseling addressing healthier eating and physical activity habits (eg, reduction of sugar-sweetened beverages, meals that are nutrient dense but not calorically dense balanced in protein and carbohydrates and low in concentrated fat, reduction of sedentary behavior, 60 min of daily physical activity)[2]	About 3% at 12 mo[28,41]	Higher frequency of contact (average of 1 h/wk over 1 y) is associated with greater BMI reduction (about 5%-10% at 12 mo) and improvement in some cardiometabolic risk factors[28]
Pharmacotherapy[2]	BMI ≥95th percentile	FDA approved for long-term use • Orlistat (60-120 mg 3 times daily orally) • Liraglutide (0.6-3.0 mg once daily subcutaneously) • Semaglutide (0.25-2.4 mg once weekly subcutaneously) • Phentermine/topiramate extended release (3.75/23 mg to 15/92 mg once daily orally) FDA approved for short-term use • Phentermine (8 mg daily to 8 mg 3 times daily or 15-37.5 mg once daily orally) Commonly used off-label • Metformin (500-2000 mg daily orally) • Topiramate (25-100 mg daily orally)	About 3% (orlistat 60-120 mg 3 times daily orally)[42] to about 17% (semaglutide, 2.4 mg, once weekly subcutaneously)[8] at 12-16 mo	Administer concurrent with lifestyle modification therapy See Table 3 for additional details including adverse effects and contraindications
Metabolic and bariatric surgery[2]	BMI ≥120% of the 95th percentile or BMI ≥35 (whichever is lower) and obesity-related complication (eg, type 2 diabetes, obstructive sleep apnea, hypertension); BMI ≥140% of the 95th percentile or BMI ≥40 (whichever is lower)	Roux-en-Y gastric bypass Vertical sleeve gastrectomy	About 30% at 12 mo with effects sustained for at least 5 y[43]	Minor (ie, hospital readmission for management of dehydration) and major (ie, abdominal reoperation) perioperative complications (30 d) occur in 15% and 8% of patients, respectively, while 13% underwent additional abdominal operations by 3 y[44] Long-term monitoring is necessary for nutritional deficiencies and bone health[2] Administer concurrent with lifestyle modification therapy

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); FDA, US Food and Drug Administration.

treatment effect on BMI of −16.7% (95% CI, −20.3% to −13.2%).[8] At 68 weeks, 73% of participants randomized to semaglutide had a 5% or greater BMI reduction and 62% had a 10% or greater BMI reduction while 18% in the placebo group had a 5% or greater BMI reduction and 8% had a 10% or greater BMI reduction. The most common adverse effects of GLP-1 RAs are nausea, vomiting, and diarrhea (Table 3), which can be mitigated by eating slowly, eating smaller meals, and avoiding high-fat and high-sugar foods. Dose de-escalation may also be needed.

Phentermine/Topiramate

Combination phentermine/topiramate extended release was approved by the FDA in 2022 for adolescents with obesity aged 12 years and older. Phentermine may reduce appetite via its action as a norepinephrine reuptake inhibitor; the mechanism by which topiramate reduces appetite and enhances satiety is not well understood.[69] A 56-week, randomized clinical trial of 227 participants aged 12 to 17 years reported a mean placebo-subtracted treatment effect of −8.1% in BMI (95% CI, −11.92% to −4.31%) for mid-dose phentermine/topiramate (7.5 mg/46 mg) and a −10.44% change in BMI (95% CI, −13.89% to −6.99%) for the highest dose of phentermine/topiramate (15 mg/92 mg).[7] An at least 5% BMI reduction was achieved by 5.4% in the placebo group vs 38.9% and 46.9% in the mid- and highest-dose phentermine/topiramate groups, respectively. An at least 10% BMI reduction was achieved by none in the placebo group vs 31.5% and 42.5% in the mid- and highest-dose phentermine/topiramate groups, respectively. Patients should be monitored for the emergence or worsening of depressed mood (in the adolescent trial, 0%, 1.9%, and 4.4% developed depression in the placebo, mid-, and highest-dose groups, respectively), and female adolescents should receive counseling on pregnancy prevention while taking this medication, given its teratogenicity.

In summary, the newer antiobesity medications appear safe and effective in adolescents. However, there are few randomized clinical trials and currently published trials are of relatively short duration. Future research should examine longer-term outcomes and potential adverse effects of these medications. Further, the decision regarding the choice of medication should include consideration of the patient's obesity severity, comorbidities and medication preferences, and the medication's effectiveness, cost, availability, and adverse effects. Additionally, because of their high cost and limited coverage by public insurance, concerns have been raised that antiobesity medications may increase racial and ethnic disparities in the prevalence of adolescent obesity.[70]

Metabolic and Bariatric Surgery

Metabolic and bariatric surgery, performed on approximately 1300 to 1900 adolescents annually in the US,[71-73] leads to reduction in mean BMI of up to 30% at 3 to 8 years.[43,44,74] Metabolic and bariatric surgery is also associated with improvements and/or resolution of hypertension, type 2 diabetes, dyslipidemia, and obstructive sleep apnea, and improvements in weight-related quality of life.[44,45,74-78] The Teen–Longitudinal Assessment of Bariatric Surgery (Teen-LABS) Study enrolled 242 adolescents with severe obesity at 5 US centers between 2007 and 2012 who received metabolic and bariatric surgery.[44] The 30-day rate of major complications (eg, reoperation) was 8% and the minor complication rate (eg, hospital readmission for dehydration) was 15%.[79] At 3-year follow-up, mean weight had decreased by 28% (95% CI, 25% to 30%) among participants who underwent Roux-en-Y gastric bypass, and by 26% (95% CI, 22% to 30%) among those who underwent vertical sleeve gastrectomy.[44] Another prospective observational study of 58 adolescents with a preoperative mean BMI of 58.5 who underwent Roux-en-Y gastric bypass reported a −29.2% BMI reduction at mean follow-up of 8 years (SD, 1.6; range, 5.4-12.5 years).[74] A study comparing 5-year outcomes among 161 Teen-LABS participants undergoing Roux-en-Y gastric bypass vs a cohort of 396 adult participants from the Longitudinal Assessment of Bariatric Surgery (LABS) consortium, who self-reported being affected by severe obesity as adolescents, showed that members of the adolescent cohort who underwent metabolic and bariatric surgery were more likely to have remission of type 2 diabetes (86% vs 53%) and hypertension (68% vs 41%) compared with their adult counterparts.[43] These data raise the possibility that the differential degree of cardiometabolic health improvement observed among adolescents compared with adults may be an important consideration for timing of surgery.

According to the recent AAP Clinical Practice Guideline, determination of eligibility for metabolic and bariatric surgery requires an individualized and multidisciplinary approach.[2,46,80] Table 2 summarizes patient eligibility criteria.

Knowledge gaps related to micronutrient deficiencies, long-term durability of weight loss, the potential need for subsequent operative interventions, and psychosocial benefits and harms of metabolic and bariatric surgery are the focus of ongoing research. Limited data suggest postsurgical micronutrient deficiencies,[81,82] including iron deficiency (45% to 71%) and deficiencies of vitamin B_{12} (20%) and vitamin D (41%),[83] and long-term bone health secondary to decreased bone mineral density[84] require further study.[45,46,79,81,85] Additionally, limited data suggest metabolic and bariatric surgery may not affect rates of depression, anxiety, or suicidal ideation among adolescents.[86-88]

In summary, evidence supports metabolic and bariatric surgery as a safe and effective intervention for adolescents with severe obesity to achieve substantial weight reduction and improvements in obesity-related complications and comorbidities.

Prognosis

Obesity in adolescence often persists into adulthood and is associated with adverse health outcomes later in life. A longitudinal study of 2392 individuals observed that 100% of adolescents with a BMI at the 99th percentile or greater had class 1 obesity (BMI ≥30) in adulthood, 88% had class 2 obesity (BMI ≥35), and approximately 65% had class 3 obesity (BMI ≥40).[5] Adolescent obesity increases the risk of mortality from cardiovascular disease and type 2 diabetes in adulthood. A longitudinal study of 2.3 million Israeli adolescents tracked the number of deaths attributed to cardiovascular causes. Adolescents with a BMI at the 95th percentile or greater at a mean age of 17.3 years had an increased risk of cardiovascular mortality with a hazard ratio of 3.5 (95% CI, 2.9 to 4.1) compared with the reference group in the fifth to 24th BMI percentiles over 40 years of follow-up.[89] In the same cohort, individuals with a mean BMI at the 95th percentile or greater at a median age of 18.4 years had increased mortality from type 2 diabetes with a hazard ratio of 17.2 (95% CI, 11.9 to 24.8) compared with the fifth to 24th BMI percentile reference group.[90]

Box 2. Questions Commonly Asked by Clinicians Regarding Adolescent Obesity Care

If intensive lifestyle treatment is not an option, are antiobesity medications still recommended?

Yes, clinicians should provide the highest level of lifestyle support available when starting antiobesity medications. Such support could include frequent office visits, meeting with a registered dietician, and/or engagement in a community program that focuses on fitness and nutrition.

Will adolescents with obesity need to continue taking medications indefinitely?

Limited evidence suggests that weight regain develops after withdrawal of antiobesity medications. However, determining whether medication dose can be reduced (or withdrawn altogether) in some patients requires further research.

What is the youngest age for which metabolic and bariatric surgery can be considered?

Based on current evidence, eligibility guidelines from the American Academy of Pediatrics (AAP) recommend referral to a comprehensive multidisciplinary obesity treatment program with surgical capabilities for patients 13 years of age or older.[2] However, the AAP also acknowledges there is limited evidence supporting surgical treatment of children younger than 13 years, which may be considered on an individual basis.[2,45,46]

Practical Considerations and Application of the Evidence

Clinicians should be supportive and compassionate, and engage in nonstigmatizing communication with adolescent patients and their families.[91] Implementation of the treatment recommendations outlined in the AAP Clinical Practice Guideline may include clinician training in motivational interviewing and partnering with community organizations to provide intensive health behavior and lifestyle treatment. The newer antiobesity medications are expensive (semaglutide costs about $1300 per month); private insurance coverage is variable, and most state Medicaid plans do not cover antiobesity medications. Lack of Medicaid coverage is particularly concerning because obesity disproportionately affects adolescents from low socioeconomic backgrounds, who are most likely to lack private insurance. Currently, about two-thirds of private insurers and most state Medicaid plans cover metabolic and bariatric surgery for adolescents,[92] yet there are a limited number of comprehensive adolescent bariatric centers, limiting access for many adolescents who meet criteria for surgery.

Table 3. Antiobesity Medications for Adolescents, Ordered by Efficacy

Medication	FDA approval	Dosing	Treatment outcomes: mean BMI reduction and additional benefits	Most common adverse events (treatment vs placebo)	Monitoring[a]	Contraindications	30-d Cost, $ (dose)[b]
Semaglutide, 2.4 mg (once weekly subcutaneous injection)[8]	Ages ≥12 y; BMI ≥95th percentile	Starting dose: 0.25 mg weekly subcutaneous for 4 wk Titration: 0.5 mg weekly for 4 wk, then 1 mg weekly for 4 wk, then 1.7 mg weekly for 4 wk, then 2.4 mg weekly	Treatment: −16.1% Placebo: +0.6% Difference: −16.7% with 2.4 mg at 68 wk Improvements in cardiometabolic risk factors (glycosylated hemoglobin, lipids, and alanine aminotransferase) and weight-related quality of life	Gastrointestinal (61.7% vs 41.8%) Nausea (42% vs 18%) Vomiting (36% vs 10%) Diarrhea (22% vs 19%)	Blood glucose if also taking insulin Heart rate Dehydration especially with severe gastrointestinal symptoms Worsening or emergence of suicidal ideation Signs or symptoms of gall bladder or pancreatic disease	Personal or family history of medullary thyroid carcinoma or multiple endocrine neoplasia syndrome type 2	1301 (2.4 mg)
Phentermine/ topiramate extended release 7.5 mg/46 mg (mid-dose) or 15 mg/92 mg (high-dose) (once daily oral)[7]	Ages ≥12 y; BMI ≥95th percentile	Starting dose: 3.75 mg/ 23 mg daily for 14 d; then 7.5 mg/46 mg daily for 12 wk If BMI has not decreased by 3% from baseline, increase to 11.25 mg/69 mg daily for 14 d, then 15 mg/92 mg daily	Treatment (15/92 mg): −7.1% Placebo: +3.3% Difference: −10.4% with 15 mg/92 mg at 56 wk About 20% decrease in triglycerides and about 10% increase in HDL cholesterol with both doses of phentermine/ topiramate	Incidence ≥4% and greater than placebo: depression, dizziness, arthralgia, influenza, and ligament sprain	Heart rate Insomnia Suicidal ideation Cognitive impairment Metabolic acidosis	Pregnancy, glaucoma, hyperthyroidism	149 (15 mg/92 mg)
Liraglutide, 3 mg (once daily subcutaneous injection)[6]	Ages ≥12 y; body weight >60 kg and BMI corre-sponding to 30 for adults	Starting dose: 0.6 mg/d subcutaneous Titration: increase dose by 0.6 mg every 4 wk to maximum tolerated dose or 3 mg/d	Treatment: −4.3% Placebo: +0.4% Difference: −4.6% with 3 mg at 56 wk No significant improvements in cardiometabolic risk factors or weight-related quality of life	Nausea (42.4% vs 14.3%) Vomiting (34.4% vs 4.0%) Diarrhea (22.4% vs 14.3%)	Blood glucose if also taking insulin Heart rate Dehydration especially with severe gastrointestinal symptoms Worsening or emergence of suicidal ideation Signs and symptoms of gall bladder or pancreatic disease	Personal or family history of medullary thyroid carcinoma or multiple endocrine neoplasia syndrome type 2	1008 (3 mg)
Orlistat, 120 mg[42]	Ages ≥12 y; BMI ≥95th percentile	120 mg by mouth 3 times daily with meals (also available over-the-counter as 60 mg 3 times daily with meals)	At 1 y: Treatment: −0.55 Placebo: +0.31 No clinically significant improvements in cardiometabolic risk factors	Gastrointestinal: fatty/oily stool, 50.3% vs 8.3%; oily spotting, 29% vs 3.9%; oily evacuation, 23.3% vs 1.7%; abdominal pain, 21.9% vs 11%	Take multivitamin supplement 2 h apart from dose	Pregnancy, chronic malabsorption, cholestasis	532 (120 mg)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); FDA, Food and Drug Administration; HDL, high-density lipoprotein.

[a] See full prescribing information for each medication for more details on adverse effects and monitoring.

[b] Data taken from Veterans Affairs' Office of Procurement, Acquisition, and Logistics (https://www.va.gov/opal/nac/fss/pharmPrices.asp).

Limitations

This review has limitations. First, this was not a systematic review so relevant studies may have been missed. Second, the authors did not perform formal quality assessment of the included studies. Third, the patient populations included in the studies of lifestyle modification therapy, pharmacotherapy, and metabolic and bariatric surgery may differ in terms of obesity severity and comorbidities, making it difficult to directly compare results among these interventions. Fourth, much of the literature did not provide results regarding the percentage of individuals achieving various target weight reductions, making it difficult to provide data about the effectiveness of interventions.

Conclusions

The prevalence of adolescent obesity is approximately 21% in the US. Treatment options for adolescents with obesity include lifestyle modification therapy, pharmacotherapy, and metabolic and bariatric surgery. Intensive lifestyle modification therapy reduces BMI by approximately 3% while pharmacotherapy added to lifestyle modification therapy can attain BMI reductions from 5% to 17%. Metabolic and bariatric surgery is the most effective and durable treatment for adolescents with severe obesity, achieving BMI reduction of approximately 30%.

ARTICLE INFORMATION

Accepted for Publication: May 31, 2024.

Published Online: August 5, 2024. doi:10.1001/jama.2024.11809

Conflict of Interest Disclosures: Dr Kelly reported engaging in unpaid consulting and educational activities, as well as serving as an unpaid investigator for Novo Nordisk; engaging in unpaid consulting activities and serving as an unpaid investigator for Boehringer Ingelheim, Lilly, and Vivus; and receiving donated drug/placebo from Novo Nordisk and Vivus for National Institute of Diabetes and Digestive and Kidney Diseases–funded clinical trials. Dr Armstrong reported serving as chair for the American Academy of Pediatrics (AAP) Section on Obesity from 2021 to 2023 and as a member of the AAP Clinical Practice Guidelines Writing Committee. Dr Michalsky reported receiving personal fees from Intuitive Surgical Inc and Lilly USA LLC. Dr Fox reported receiving research support from Novo Nordisk and Lilly for serving as a site principal investigator; compensation for this work was paid directly to her institution.

Submissions: We encourage authors to submit papers for consideration as a Review. Please contact Kristin Walter, MD, at kristin.walter@jamanetwork.org.

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