Review

# Weight management for overweight and obese adolescents: Current treatments

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**Background and Objectives:** The prevalence of overweight or obesity in adolescents is steadily increasing in most countries around the world. Adolescent obesity increases the risk of chronic diseases such as cardiovascular disease, and is associated with negative health consequences, increasing the burden on health services. **Methods and Study Design:** Literature searching was conducted in PubMed and Google Scholar using the keywords "overweight", "obesity", "adolescent", "weight management", "dietary management" and "nutritional intervention" combined with Boolean operators "AND" and "OR". **Results:** Multicomponent lifestyle interventions, including diet, physical activity, and behavioural interventions, are used as first-line treatment for anti-obesity interventions. Dietary management methods such as energy-restricted diet are beneficial to control body weight, and it is important to ensure their normal growth and development while restricting energy. **Conclusions:** Multicomponent lifestyle intervention is the first choice for anti-obesity intervention. It is recommended that intensive health behaviour lifestyle treatment combined with anti-obesity medications be used at the beginning of anti-obesity treatment in adolescents.

**Key Words: weight management, overweight, obesity, adolescent, multicomponent lifestyle intervention**

## INTRODUCTION

A recent meta-analysis revealed that the worldwide prevalence of obesity in children and adolescents was 8.5% (95% CI, 8.2 to 8.8) and the prevalence of overweight in adolescents was 22.2% (95% CI, 21.6 to 22.8).[1] From 1990 to 2022, the global prevalence of obesity among adolescents has increased.[2, 3] The estimated number of girls and boys with obesity in 2022 was 65.1 million (95% CI, 59.4 to 71.7) and 94.2 million (95% CI, 85.3 to 103.0), respectively, an increase of 51.2 million (95% CI, 45.2 to 57.8) and 76.7 million (95% CI, 67.6 to 85.7), respectively, since 1990.2 Obesity in adolescents is defined as body mass index (BMI) more than 2 standard deviations above the median world health organization (WHO) growth reference value.[4] The prevalence of obesity among 12- to 19-year-old in the United States has increased steadily, from 16.8% (95% CI, 14.2 to 19.8) in 2007-2008 to 18.5% (95% CI, 15.8 to 21.3) in 2015-2016.[3, 5, 6] In China, the 2015 national survey revealed that the prevalence of obesity in children and adolescents aged 7-17 years was 13.2% (95%CI, 12.8 to 13.7).[7]

It should be emphasized that adolescent obesity is a chronic condition requiring lifelong care.[8, 9] Clinical evidence shows that persistent obesity in adolescents increases the risk of chronic diseases such as cardiovascular disease, hypertension, diabetes mellitus and future cancer.[10-14] Based on the data from the global burden of disease collaborative for 2000 and 2013, it is estimated that by 2025 global childhood and adolescent obesity will lead to 12 million children and adolescents with impaired glucose tolerance, 4 million with type 2 diabetes, 27 million with hypertension and 38 million with hepatic steatosis.[15] There is also a growing recognition that adolescent obesity is associated with a range of immediate and long-term negative health consequences, reduced quality of life, increased economic costs for individuals and society, and increased burden on health services.[16, 17] In addition, the adolescent period is characterized by the development of autonomy and self-identity, and the adolescents with overweight and obesity is prone to low self-esteem, depression and anxiety, which will affect mental health status and quality of life.[1, 16, 18]

Lifestyle interventions, including dietary management, play an important role in the treatment of adolescents overweight and obesity, and recent clinical studies have provided reliable evidence of the meaningful reduction in

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body weight of anti-obesity medications.[8, 19] This review focuses on the risk factors and pathophysiology of overweight and obesity in adolescents, as well as approaches to its treatment for weight management.

## METHODS

Literature searching was conducted in PubMed and Google Scholar using the keywords "overweight", "obesity", "adolescent", "weight management", "dietary management" and "nutritional intervention" combined with Boolean operators "AND" and "OR".

This review included peer-reviewed clinical trials, systematic reviews, and meta-analyses published in English that evaluated the effects of anti-obesity treatments such as dietary interventions, exercise interventions, anti-obesity medications, and metabolic surgery on weight management in adolescents with overweight or obesity.

## RESULTS

### *Risk factors and possible pathogenesis of overweight and obesity in adolescents*

Unlike childhood obesity, which is linked to many environments in early life, genetic, lifestyle, behavioural, social, and environmental factors are major risk factors for obesity in adolescents.[20, 21] Obesity, dominated by polygenic variants, is the result of interactions between genetic predisposition and environmental factors.[22] Many lifestyle and behavioural factors increase the risk of obesity, including reduced physical activity, being sedentary, short and poor sleep duration, fast food, carbonated soft drink intake, and no daily vegetable intake.[23-26] Social and environmental factors include chronic psychosocial stress, widespread marketing of food and beverages to adolescents, a shift from conventional to ultra-processed foods, loss of walkable green spaces in many urban settings, increased motorized transportation, rapid changes in the use of technology, and environmental contaminants, et al.[20, 27, 28] Individual, social, and environmental risk factors often overlap and/or influence each other and may have longitudinal effects throughout adolescence, leading to weight gain and exacerbating existing obesity.[8]

The simple explanatory model of obesity (too much caloric intake and too little physical activity) has been replaced by a complex multi-component model that includes genetics, social and cultural backgrounds, obesogenic environment, and the barriers to treatment.[9] Body weight is primarily regulated by two systems: energy homeostasis and cognitive-emotional control, and obesity occurs when genetic and epigenetic factors, behavioural risk patterns, and broader social and environmental factors influence both systems.[20, 29] One is a homeostatic system operating at an unconscious level regulated primarily by brain centres in the hypothalamus and brainstem, receiving long-term signals from energy stores in adipose tissue (such as leptin) and short-term hunger and satiety signals from the gastrointestinal tract.[20, 30] Another non-homeostatic system (cognition-emotion control) is regulated by higher brain centres and operates at the level of consciousness, when homeostatic signals are integrated in the thalamus, combined with stimuli from the environment, experience and emotion, and then induced emotional and cognitive impulses to control food intake.[20, 29, 31]

The above risk factors and possible pathogenesis are summarized in Table 1. Meanwhile, Table 2 summarizes the interventions and strategies for adolescents with overweight and obesity.

### *Dietary management in adolescents with overweight and obesity*

Obesity is a chronic disease that should be treated using intensive and long-term care strategies that provide continuous anti-obesity treatment and medical monitoring, a key component of anti-obesity treatment is simultaneous monitoring and treatment of comorbidities, which are not discussed in our review.[8] Nutritional therapy including diet management is the preferred treatment for overweight and obesity in adolescents, and it is important to ensure their normal growth and development while restricting energy.[32] Medical nutrition therapy aims to achieve positive health outcomes in addition to weight management, and obesity-related complications and other comorbidities should be managed independently of any anti-obesity treatment.[33] A recent meta-analysis suggests that obesity interventions that include dietary components significantly reduce average total energy intake, increase fruit and/or vegetable intake, and reduce the consumption of sugar-sweetened beverages in adolescents with over-

**Table 1.** Summary of risk factors and possible pathogenesis of overweight and obesity in adolescents

| Risk factors and pathogenesis | Details |
|---|---|
| Risk factors | Genetic: Polygenic variants interact with environmental factors.<br>Lifestyle & Behavioural: Reduced physical activity, sedentary lifestyle, poor sleep, fast food, carbonated drinks, no daily vegetable intake, et al.<br>Social & Environmental: Chronic psychosocial stress, food marketing to adolescents, shift to ultra-processed foods, loss of green spaces, increased motorized transport, tech changes, environmental contaminants. |
| Pathogenesis model | Complex multi-component model replacing the simple "calories in - calories out" model.<br>Includes genetics, social-cultural backgrounds, obesogenic environment, and treatment barriers. |
| Regulatory systems of body weight | Energy Homeostasis: Unconscious system regulated by hypothalamus and brainstem. Receives long-term signals from adipose tissue (e.g., leptin) and short-term hunger/satiety signals from the gut.<br>Cognitive-Emotional Control: Conscious system regulated by higher brain centres. Integrates homeostatic signals in the thalamus with environmental, experience, and emotion stimuli to control food intake. |

**Table 2.** Summary of interventions for adolescents with overweight and obesity

| Intervention type | Intervention strategies |
|---|---|
| Lifestyle interventions | Multicomponent lifestyle interventions are used as first-line treatment for anti-obesity interventions. |
| Dietary management | Energy restriction diet is beneficial for adolescents to control body weight, and reduce energy supply on the premise of ensuring the energy required for normal growth and development.<br>Structured meal plans, portion control, and meal replacements can be used as possible weight management interventions.<br>Dietary management emphasizes a balanced and healthy diet, and requires assessing and addressing modifiable risk factors in eating habits. |
| Physical activity | It is recommended 30 minutes moderate-intensity aerobic exercise at least 5 days a week, combined with strength or resistance training. |
| Behavioural management | Intensive healthy behaviour and lifestyle treatment requires patient and family collaboration with multidisciplinary treatment teams to conduct health education and skill training.<br>Motivational home-based or school-based behavioural interventions are recommended. |
| Anti-obesity medications | Intensive health behaviour lifestyle treatment in combination with anti-obesity medications is recommended at the beginning of anti-obesity treatment in adolescents.<br>Various anti-obesity medications, including glucagon-like peptide-1 receptor agonists, can reduce body weight and body mass index, but serious adverse events should be alert. |
| Metabolic surgery | Metabolic bariatric surgery must strictly adhere to clinical guideline indications and requires long-term multidisciplinary follow-up care. |

weight or obesity.[34]

Energy restriction diet is beneficial for overweight and obese adolescents to control body weight, and reduce energy supply on the premise of ensuring the energy required for normal growth and development, and prevent any impact upon growth under the supervision of a health professional such as a dietitian.[32, 35] To reduce body weight, dietary interventions should be provided by nutrition professionals to produce an energy deficit of 500 to 750 kcal per day.[33] Structured meal plans, portion control, and meal replacements as possible weight management interventions for adolescents, and the Mediterranean diet, vegetarian diet, the Dietary Approaches to Stop Hypertension, and low-carbohydrate diet have been shown to be associated with improved metabolic health, with or without weight change.[33, 35] The current guidelines do not emphasize the dietary composition of nutritional therapy, but focus on balanced and healthy diets.[33] The unique characteristics of adolescent development can influence food choices, and adolescents should be actively involved in developing healthy dietary patterns.[36] Recent studies have focused on intermittent energy restriction as a treatment option for obesity, but there is no evidence that intermittent energy restriction has significant advantages over continuous energy restriction.[33, 37, 38] Very low-calorie diets (calorie intake $\leq$ 800 kcal/ day) are not recommended for the treatment of obesity but only for certain medical conditions, which always requires medical supervision.[32, 33]

Other types of dietary management have also been explored in several clinical studies. The 24-week low-energy anti-inflammatory diet intervention significantly reduced body weight and visceral adipose tissue, and improved cardiometabolic and inflammatory status in obese patients.[39] A randomized controlled trial did not observe a significant effect of a high protein/low glycemic index diet intervention versus a moderate protein/moderate glycemic index diet intervention on insulin resistance in overweight/obese adolescents.[40] A meta-analysis showed that dietary management were associated with a reduction in the prevalence of eating disorders, risk of eating disorders, and symptoms in children and adolescents with overweight or obesity.[41] When using diet management for overweight and obesity, pediatricians should also assess and address modifiable risk factors for obesity, including the frequency of eating out and fast-food consumption.[42, 43]

***Physical activity and behavioural management in overweight or obese adolescents***

In addition to dietary intervention, comprehensive lifestyle interventions include physical activity and behavioural intervention.[8, 33, 44] Increasing daily activities and physical exercise are beneficial to increase energy expenditure in adolescents with overweight and obesity, which combined with dietary intervention can keep energy metabolism in a negative balance.45 It is recommended 30 min moderate-intensity aerobic exercise at least 5 days or more per week, combined with strength or resistance training.[45] In children and adolescents with moderate-to-severe obesity, a 16-week exercise intervention significantly reduced percentage body fat and cardiometabolic risk markers and increased lean mass and leg muscle strength compared with a usual-care multidisciplinary lifestyle intervention program.[46] There is high-quality study revealed that physical activity interventions improve average cognitive executive function scores in children and adolescents with overweight or obesity.[47] Play-based physical activity and nutrition advice interventions can improve quality of life in overweight and obese children.48 Short-term low-volume high-intensity interval training is an effective way to improve the cardiorespiratory fitness of adolescents, which suggests that participation in physical education classes in the school curriculum has health benefits.[49] Exercise interventions targeting special groups such as those with comorbid asthma or psychological disorders require additional adjustments,

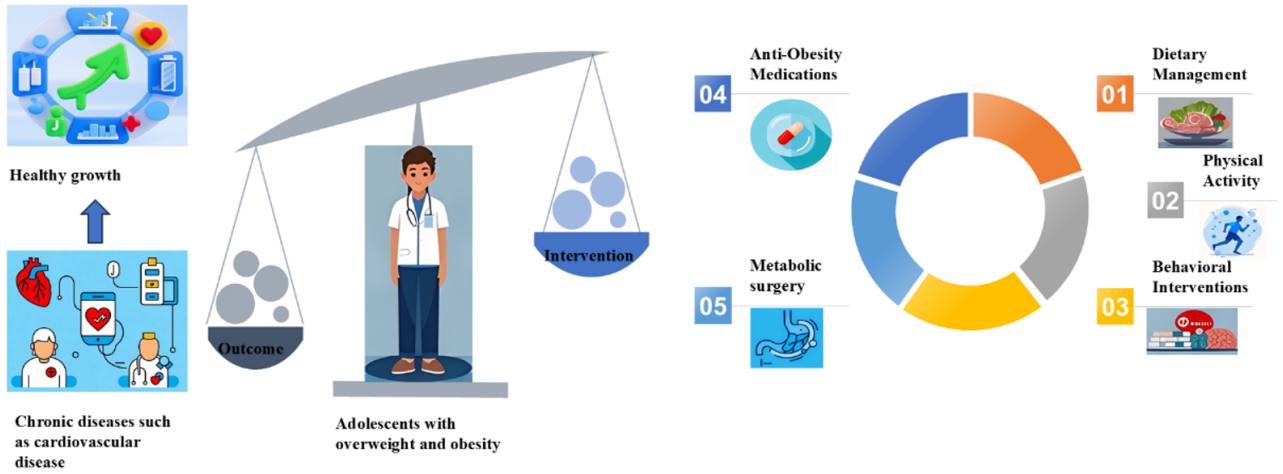


**Figure 1.** Graphical abstract

increased control of underlying diseases, family support, and social support.[50, 51]

Multicomponent lifestyle interventions, including diet, physical activity, and behaviour modification, are used as first-line treatment for anti-obesity interventions.[35] Intensive healthy behaviour and lifestyle treatment is an essential approach to promote the maintenance of healthier eating and physical activity habits to achieve weight management in adolescents, in which patients and families cooperate with multidisciplinary treatment teams to conduct health education and skill training on multiple topics, behaviour change and counselling.[8, 52, 53] The main views of adolescents who had participated in anti-obesity interventions were "fear of receiving life intervention before intervention", "hope for long-term support", "enjoy sports and physical activity", and "strong motivation to improve body image and social goodwill", and consideration of the above perspectives may help policy makers to formulate future interventions.[54] Intensive behavioural intervention programs can reduce BMI, reduce comorbidities, and improve quality of life in children and adolescents.[8, 55, 56] Comprehensive, intensive behavioural interventions (≥ 26 h of contact) in obese children and adolescents aged 6 years and older can improve weight status for up to 12 months.[57]

A multi-centre study in India showed that school-based lifestyle intervention was more effective in improving physical activity, lifestyle behaviours and quality of life in adolescents than exercise intervention alone.[58, 59] A motivation-based educational program is more effective than dietary counselling in reducing wrist circumference and improving quality of life among adolescents with overweight and obesity.[60] Parents and caregivers can play a key role in the treatment of obesity through strategies such as parental supervision and changing the family environment, and studies have found that family-based interventions have a significant indirect effect on the treatment of obesity through the quality of parent-child relationship and dietary attitudes.[61, 62] Current evidence suggests that behaviour-oriented prevention programs have limited long-term effects, and behaviour-based programs can be combined with community-based prevention to combat "obesogenic environments".[20, 63]

***Anti-obesity medications and metabolic surgery***

The new clinical practice guideline recommends that anti-obesity medications therapy be provided to adolescents with obesity in parallel with intensive health behaviour lifestyle treatment, which represents a paradigm shift from pharmacotherapy when lifestyle therapy fails to a combination of intensive health behaviour lifestyle treatment and anti-obesity medications from the start of treatment.[8, 9]

A recent meta-analysis provides evidence that anti-obesity medications reduce BMI (-1.71, 95% CI: -2.27 to -1.14), but may require dose modifications, with 1 in 100 adolescents experiencing serious adverse events, with semaglutide achieving the greatest reduction in BMI (-5.88, 95% CI: -6.99 to -4.77).[19] Another meta-analysis provided solid evidence for the effect of glucagon-like peptide-1 receptor agonists (GLP1Ras) on weight loss in non-diabetic individuals with overweight or obesity, with significant weight loss (MD -5.319 kg, 95% CI: -6.465 -- 4.174), BMI (MD-2.373 kg/m(2), 95% CI: -2.821 to 1.924), and waist circumference (MD - 4.302 cm, 95%CI :-5.185 to 3.419).[64]

In overweight or obese participants, semaglutide plus lifestyle intervention was associated with weight loss and a greater reduction in abdominal visceral fat area, suggesting that this is a promising treatment option for weight management.[65, 66] A phase III clinical trial found that liraglutide significantly reduced BMI in obese adolescents.[67, 68] A randomized controlled trial showed that orlistat improved liver enzymes, body weight, BMI, waist circumference, total cholesterol, and low-density lipoprotein cholesterol in overweight/obese adolescents with non-alcoholic fatty liver disease.[69] An economic evaluation study of quality-adjusted life-years, costs, and incremental cost-effectiveness ratios for anti-obesity medications suggested that the top-dose phentermine and topiramate assisted lifestyle counselling was estimated to be cost-effective after 5 years.[70]

Anti-obesity medications may play a role in combating the pathophysiology of the development of obesity in adolescents through the following mechanisms. GLP1Ras reduce appetite by acting on hypothalamic glucagon-like peptide-1 receptors, increasing satiety and reducing food reward and craving by activating the hindbrain and slow-

ing gastric emptying.[71] Phentermine reduces appetite by inhibiting reuptake of norepinephrine, and topiramate reduces caloric intake by increasing gamma-aminobutyric acid activity and inhibiting carbonic anhydrase.[71]

Relevant clinical guidelines recommend that metabolic and bariatric surgery be considered for youth with class II obesity (defined as a BMI of 120% of the 95th percentile) or class III obesity (defined as a BMI of 140% of the 95th percentile) with comorbidities such as type 2 diabetes and obstructive sleep apnea.[8, 72] Metabolic and bariatric surgery includes adjustable gastric band, sleeve gastrectomy, Roux-en-Y gastric bypass and biliopancreatic diversion/duodenal switch.[73] After bariatric surgery, long-term multidisciplinary follow-up care is required, including diet and micronutrient monitoring, individualized nutritional supplementation and psychological support.[33]

### *Conclusion*

The prevalence of adolescent obesity has been steadily increasing in most countries around the world, and adolescent obesity increases the risk of chronic diseases such as cardiovascular disease. Multicomponent lifestyle interventions, including diet, physical activity, and behavioural interventions, are used as first-line treatment for anti-obesity interventions. It is important to maintain normal growth and development on an energy-restricted diet, while increasing daily activity and physical exercise is also necessary. Clinical practice guidelines recommend combining intensive health behaviour lifestyle treatment with anti-obesity medications at the beginning of anti-obesity treatment in adolescents. A variety of anti-obesity medications can significantly reduce body weight and BMI, but serious adverse events should be alert. Metabolic bariatric surgery should strictly follow the indications of clinical guidelines, and long-term multidisciplinary follow-up care is needed.

## SUPPLEMENTARY MATERIALS

All supplementary materials are available upon request to the editorial office.

## CONFLICT OF INTEREST AND FUNDING DISCLOSURES

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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