# **BMJ** Best Practice Obesity in children

The right clinical information, right where it's needed



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# Summary

- Behavioural and environmental factors are primarily responsible for the dramatic increase in obesity in the past 2 decades, although genes play an important role in regulation of body weight.
- Calculating body mass index (BMI) is the most widely accepted method of screening for obesity in children. Abnormal BMI cut-offs in children are determined by age- and gender-specific percentiles.
- The dramatic increase in childhood obesity has led to a marked increase in the diagnosis of impaired glucose tolerance and type 2 diabetes mellitus in children.
- Preventing excessive weight gain in children is of paramount importance in confronting the obesity epidemic, as obesity is difficult to treat at all ages, and obese children tend to become obese adults.
- The mainstay of treatment is lifestyle modification to improve diet and increase physical activity. Pharmacotherapy and bariatric surgery may be considered as an adjunct to lifestyle modification in morbidly obese adolescents.

### **Basics**

# Definition

Obesity is a condition of excessive body fat or adiposity that exceeds healthy limits. The most widely accepted method to screen for excess adiposity is calculation of body mass index (BMI).[1] Abnormal BMI cut-offs in children are determined by age- and gender-specific percentiles based on growth charts, as the amount of body fat changes with age and differs between boys and girls.[2] Worldwide, the definition of overweight and obesity changes; however, a BMI >85th percentile is defined as overweight or at risk for overweight in the US and UK, a BMI ≥95th percentile is variably defined as obesity or overweight, and a BMI >99th percentile is defined as morbid obesity.[3] [4] For children under 2 years of age, BMI percentiles are not available; thus, obesity may be defined as a weight ≥95th percentile for height.[3]

# Epidemiology

In the UK in 2006, it was estimated that 16% of children aged 2 to 15 years were obese (boys 17%, girls 15%).[5] In Scotland, the increase in obesity prevalence in children and adolescents has been accelerating since the mid-1980s; between 1987 and 2006 the prevalence increased 2.5 times in Scottish 15-year-olds.

In the US, data obtained from the National Health and Nutrition Examination Survey (NHANES) provide estimates of the prevalence of overweight and obesity (body mass index [BMI]  $\geq$ 85th percentile) among children and adolescents. Data demonstrate that the prevalence of obesity among US children has been increasing since 1990.[6] However, data from NHANES from 2003 to 2014 suggest that this trend in obesity prevalence in children and adolescents is levelling off, except in the very heaviest 6- to 9-year-old boys.[7] [8] [9] [10] In addition, the prevalence of obesity in children aged 2 to 5 years appeared to be declining in 2011 to 2014.[9] [10] [11]

BMI	Dates	2-19 years	2-5 years	6-11 years	12-19 years
≥85 <sup>th</sup> percentile	1999-2000	28.2%	22.0%	29.8%	30.0%
	2003-2006	31.9%	24.4%	33.3%	34.1%
	2007-2008	31.7%	21.2%	35.5%	34.2%
	2009-2010	31.8%	26.5%	32.6%	33.6%
	2011-2012	31.8%	22.8%	34.2%	34.5%
$\geq$ 95 <sup>th</sup> percentile	1999-2000	13.9%	10.3%	15.1%	14.8%
	2003-2006	16.3%	12.4%	17.0%	17.6%
	2007-2008	16.9%	10.4%	19.6%	18.1%
	2009-2010	16.9%	12.1%	18.0%	18.4%
	2011-2014	17.0%	8.9%	17.5%	20.5%

Prevalence of overweight and obesity in US children according to age

Adapted from NHANES surveys 1999-2014

Significant differences exist between racial/ethnic groups, with Mexican-American boys and girls having the highest prevalence of overweight and obesity in the US.[9]

BMI	Racial/Ethnic group	Males (2-19 years)	Females (2-19 years)
≥85 <sup>th</sup> percentile Non-Hispanic white		27.8%	29.2%
	Non-Hispanic black	34.4%	36.1%
	Mexican-American	40.7%	37%
$\geq$ 95 <sup>th</sup> percentile	Non-Hispanic white	12.6%	15.6%
	Non-Hispanic black	19.9%	20.5%
	Mexican-American	24.1%	20.6%

Prevalence of overweight and obesity in US children according to racial/ethnic group and gender Adapted from NHANES survey 2011-2012

In addition, in the most recent NHANES survey, 8.1% of infants and toddlers were ≥95th percentile on the weight for height growth charts. Overall estimates of childhood obesity tend to be higher in the US as compared to other countries.[9]

# Aetiology

Obesity in children is multifactorial. Interactions among factors such as genetic predisposition, behavioural and cultural practices, and environmental influences lead to discordant energy balance, with energy intake exceeding energy expenditure, eventually leading to obesity in predisposed people. Many factors typically co-exist in a person, making it difficult to determine the impact of any one factor independently of the others on the development of obesity. Behavioural and environmental changes must play an important role even in genetically predisposed children, as the prevalence of obesity in children has increased dramatically over the last 30 years despite a low likelihood of a rapid change in the genetic makeup of the population.

### Genetic predisposition

- A child's risk of obesity is increased with ≥1 obese parents.[12]
- Epidemiological studies have shown that children from ethnic minorities have a higher incidence of obesity, especially during adolescence. In the US, Mexican-American boys and girls currently have the highest prevalence of overweight and obesity. In addition, degrees of physical activity differ between racial groups.[7] [9] [10] [12] [13] [14] [15]

Behavioural practices

- Poor dietary habits leading to increased energy intake, including energy-dense foods, large portion sizes, fast food, and sugary beverages, are thought to play a role in the development of obesity.[16]
- In addition, decreased physical activity is likely to play a role, and studies suggest that most children in high school do not meet recommended levels of physical activity.[17]
- Children also tend to have increased sedentary behaviour, including increased time spent watching television, playing video games, or on the computer. This may lead to less physical activity and increased food intake. Obesity risk is increased in children who have screen time (e.g., television, video games, internet) greater than 2 to 3 hours per day.[18]
- Rapid weight gain during infancy has been associated with an increased risk of childhood obesity.[19]
   [20]
- Children with early-onset obesity in childhood including those with body mass index (BMI) >85th percentile between the ages of 24 and 54 months have a 5-fold greater likelihood of being overweight at 12 years of age. In addition, children with a BMI >50th percentile are prone to be overweight by

adolescence.[13] Children who are already obese at age 8 years will tend to have more severe obesity, as well as increased morbidity as an adult.[21] [22]

• Epidemiological studies show a link between short sleep time and development of obesity in infants, children, and adolescents.[23] [24] [25]

#### Environmental influences

- Technological advances have led to a decrease of physical activity.
- In addition, energy-dense foods and high-sugar beverages are easily available both in schools and in the community, and are often less costly than healthier alternatives.
- Children raised in poor families have a higher risk of obesity.[26]
- Maternal gestational diabetes may lead to fetal hyperglycaemia and hyperinsulinism affecting body size at birth, which may play a role in later development of obesity.[27]
- Poor nutrition in utero has been shown to be correlated with obesity in childhood and adulthood.[26]

Obesity may also result from medical causes such as endocrine disorders (e.g., hypothyroidism, Cushing syndrome, pseudohypoparathyroidism, hypothalamic obesity following surgery for a craniopharyngioma) and genetic syndromes (e.g., Prader-Willi syndrome, Bardet-Biedl syndrome), or from medications (e.g., neuropsychiatric medications, corticosteroids).

# Pathophysiology

Several physiological systems control how the body regulates its weight. The arcuate nucleus, located in the hypothalamus, serves as the master centre of weight regulation by integrating hormonal signals that direct the body to adjust its food intake and energy expenditure.

The arcuate nucleus contains 2 major types of neurons with opposing actions. Activation of the peptide neurotransmitters neuropeptide Y (NPY) and agouti-related peptide (AgRP) leads to stimulation of appetite and decrease in metabolism. In contrast, activation of pro-opiomelanocortin (POMC)/cocaine and amfetamine-regulated transcript neurons causes release of melanocyte-stimulating hormone, which inhibits eating.

Short-term feeding has been linked to 2 peptide hormones produced in the digestive tract, ghrelin and peptide YY, which control how much and how often we eat on a given day. Ghrelin is a potent appetite stimulator that is produced in the stomach and activates the NPY/AgRP neurons. Increased ghrelin levels are associated with meal initiation. Peptide YY may play an important role in satiety, as it activates the POMC neurons while inhibiting the NPY/AgRP neurons. Longer-term weight regulation, over months to years, is linked to leptin and insulin.[28]

When fat stores and leptin levels decrease, NPY/AgRP neurons are activated and POMC neurons are inhibited, thereby stimulating weight gain. The opposite occurs with increased fat mass and increased leptin levels.

[Fig-3]

# **Primary prevention**

Preventing childhood obesity is of paramount importance in controlling the obesity epidemic. Preventative strategies must begin early in life, as obesity is difficult to treat at all ages, and obesity tends to persist into adulthood.[12] [31] Breastfeeding has been shown to be associated with a lower incidence of obesity in childhood.[32] However, the data are inconsistent, with other studies showing no obvious effect.[33] Promotion of breastfeeding is still recommended based on other health benefits.

The American Academy of Pediatrics' recommendation to avoid offering juice to infants aged 6 months and under has been expanded to include infants aged 12 months and under, as juice offers infants no nutritional benefits and can predispose them to inappropriate weight gain. Consumption should be limited to 170 mL per day for children aged 4 to 6 years, and 230 mL per day for children aged 7 to 18 years.[34]

A systematic review found that school-based preventative interventions with combined diet and physical activity components, as well as a home element, were effective. The review included 41 studies from all over the world. A paucity of studies and heterogeneity in study design limited the conclusions that could be drawn regarding only preschool-based, only community-based, and only home-based interventions.[35]

A child's body mass index (BMI) should be calculated and plotted at least annually, and the child's dietary history and physical activity history should be reviewed during routine well-child visits. Family history of obesity and the child's BMI trajectory should also be assessed. Anticipatory guidance encouraging healthy behaviours to decrease obesity risk should be provided routinely to all children, regardless of current BMI.[36]

# Screening

Many children do not present with a complaint of obesity or rapid weight gain. It is therefore important that all children be screened for obesity risk with calculation and plotting of body mass index (BMI) on an annual basis, especially those with a family history of obesity or those with a history of intrauterine growth restriction.[52] It is essential that all children and their families be informed of healthy eating and activity habits at a young age in the hopes of preventing a condition that is difficult to treat at any age and that often persists into adulthood.

# Secondary prevention

Discussion of healthy nutrition and physical activity for children should be part of the anticipatory guidance given at all well-child visits. Body mass index (BMI) should be calculated and plotted at least yearly to identify those children who are overweight or obese, or who may be at risk for obesity. Public health strategies need to be further developed to promote healthy lifestyle choices for children in the schools, with extension to the community.[128] [129] Schools need to offer healthy food choices, and children should have daily physical education. In addition, fun and safe places to exercise should be provided in the community. Advertising of fast foods and energy-dense foods directly to children should be restricted.

# Case history

# Case history #1

An 8-year-old white girl presents for further evaluation of excessive weight gain and acanthosis nigricans. She was born at term following a pregnancy complicated by gestational diabetes, and had a birth weight of 4.5 kg. Her weight was >95th percentile for height by 2 years of age and has been accelerating further away from the normal weight curve since. She has followed the 95th percentile for height. She has a large appetite with excessive calories eaten throughout the day. She has limited activity, and watches 5 to 6 hours of television daily. She had a tonsillectomy and adenoidectomy for obstructive sleep apnoea at 6 years of age. There is an extensive family history of obesity, and her father's body mass index (BMI) is 35 and mother's BMI is 45. The child's height is 143 cm, and weight 80 kg, giving her a BMI of 38.8, which is markedly greater than the 95th percentile for age and gender.

# Case history #2

A 15-year-old black girl presents for evaluation of irregular periods and acne. Excessive weight gain is not a primary concern of the family, and they feel that she is simply "big-boned". However, her weight has been >97th percentile since 5 years of age, with acceleration further above the normal weight curve since. Both parents are obese with type 2 diabetes. Her father also has hyperlipidaemia and had a myocardial infarction at 47 years of age. The child drinks at least 5 cans of regular soft drinks daily and eats at fast food restaurants several times weekly. She has limited physical activity. Her height, weight, and BMI are 168 cm, 121.2 kg, and 42.8, respectively.

# Other presentations

Children who have obesity associated with hormonal abnormalities (e.g., hypothyroidism, Cushing syndrome) typically present with short stature and other symptoms specific to the condition. Children with syndromic obesity, such as Prader-Willi syndrome and Bardet-Biedl syndrome, often have developmental delay, dysmorphic features, and hypogonadism in addition to having short stature. Children can also present with hypothalamic obesity following treatment for intracranial lesions such as craniopharyngioma.

# Step-by-step diagnostic approach

Diagnosis is based primarily on a thorough history and examination in conjunction with the child's body mass index (BMI). Waist circumference and skinfold thickness may be used to support the diagnosis. Imaging techniques are rarely used.

### History

Children who have 1 or 2 obese parents are at higher risk of developing obesity,[12] as are children who are overweight at a young age, children from ethnic minorities, and children raised in poor families.[13] [26] [37] Maternal history of gestational diabetes or poor nutrition during pregnancy should be noted.[26] [27] The child may have been born small for gestational age.

Reviewing dietary history is important to assess potential modifiable dietary choices. Assessing daily exercise patterns is also important, as sedentary behaviour (e.g., computer/television screen time >2-3 hours/day) has been associated with obesity.[29]

Many children do not present with a specific complaint of obesity or rapid weight gain; thus, screening for excess adiposity is important at all visits.

Patients may present with symptoms of complications/comorbidities associated with obesity including headache (associated with hypertension and pseudotumor cerebri), snoring or daytime somnolence (obstructive sleep apnoea), abdominal pain (cholelithiasis), hip pain (slipped capital femoral epiphysis), polyuria or polydipsia (type 2 diabetes), or irregular menses and/or hirsutism (polycystic ovary disease).

A full medical and family history should also be obtained to rule out other causes of obesity due to disease such as hypothyroidism, Cushing syndrome, pseudohypoparathyroidism, and hypothalamic obesity following surgery for a craniopharyngioma. Medication history for drugs such as neuropsychiatric medications and corticosteroids should be elicited.[14] Children with gene mutations present with severe, early-onset obesity, usually associated with disruption of normal appetite control mechanisms.

### **Physical examination**

Children who are overweight or obese have a higher prevalence of hypertension; thus, blood pressure should be measured.[38] Acanthosis nigricans is often seen in obese children and is associated with insulin resistance. Acne and/or hirsutism is associated with polycystic ovary syndrome.

Short stature associated with obesity should raise the suspicion of a hormonal abnormality as the cause of obesity (e.g., hypothyroidism, Cushing syndrome). Developmental delay, dysmorphic features, and hypogonadism in addition to short stature suggest a genetic syndrome such as Prader-Willi and Bardet-Biedl syndromes. Hypogonadism may also be present with leptin deficiency, and red hair and hypocortisolism are observed in pro-opiomelanocortin deficiency.

### Indices of body fat

BMI

- The most widely accepted measure of body fat is the BMI (weight in kilograms divided by height in metres squared).[3] Accurate measurements of both height and weight are therefore very important.
- Abnormal BMI cut-offs in children are determined by age- and gender-specific percentiles based on growth charts.[2] Worldwide, the definition of overweight and obesity changes; however, a BMI >85th percentile is defined as overweight or at risk for overweight in the US and UK, a BMI ≥95th percentile is variably defined as obesity or overweight, and a BMI >99th percentile is defined as morbid obesity.[3] [4] For children <2 years of age, BMI percentiles are not available; thus, obesity may be defined as a weight ≥95th percentile for height.[3]
- Although BMI is an indirect measure of body fat, it has been found to correlate with adiposity.[1]
   [39] It, however, does not distinguish between subcutaneous and visceral fat (which has been shown to be associated with cardiovascular and metabolic risk factors).[40] [41] Children who are very muscular may have a BMI in the abnormal range despite having normal to low adiposity.

Waist circumference

- Waist circumference or waist-hip ratio can be used as an indirect measure of visceral adiposity (which has been shown to be associated with cardiovascular and metabolic risk factors).[40] [41]
- Measurement of waist circumference is non-invasive and may be helpful in addition to BMI to identify overweight children at a higher metabolic risk.
- Waist circumference percentiles have been developed for children aged 2 to 19 years.[2] However, the cut-off values that would indicate risk above that of BMI measurement are not available.[14]
- In adults, waist circumferences >102 cm for men and >88 cm for women are associated with an increased risk of metabolic problems.[42]

#### Skinfold thickness

- Skinfold thickness provides information about body fat and the risk of medical complications.[43]
- However, it is difficult to perform accurately, and reference data in children are not readily available. It is not recommended in the general clinical setting.

### Investigations

Investigations to screen for common complications/comorbidities:

- Fasting lipoproteins to screen for dyslipidaemia in children with a BMI ≥85th percentile[21]
- Fasting glucose to screen for type 2 diabetes mellitus
- LFTs to screen for non-alcoholic fatty liver disease.

Investigations to identify medical causes of obesity depend on the patient's symptoms and presentation (e.g., short stature, fatigue, violaceous striae, hirsutism, irregular menses, dysmorphic features), but could include:

- Thyroid function tests for hypothyroidism
- Urinary-free cortisol or midnight salivary cortisol for Cushing syndrome
- Serum calcium, phosphate, and parathormone for pseudohypoparathyroidism
- · Hypothalamopituitary testing in hypothalamic obesity following surgery for craniopharyngiomas
- Therapeutic trial of discontinuing medications such as neuropsychiatric medications and corticosteroids suspected of causing obesity where possible[14]
- · Genetic testing in patients suspected of having:
  - Monogenic obesity
  - Bardet-Biedl syndrome
  - Prader-Willi syndrome.

Appropriate tests for the primary care physician to obtain include fasting lipoproteins, fasting glucose, a comprehensive metabolic panel, and thyroid function tests. The physician should consider referring the patient to a paediatric endocrinologist if any of these tests are abnormal, or if more specific tests such as urinary-free cortisol, midnight salivary cortisol, pituitary hormones, or genetic testing are thought to be needed.

#### Emerging investigations

• DEXA is a safe method for assessing total body fat. However, its use is limited by the expense of the method and the inability to distinguish between subcutaneous and visceral fat. It is used mainly in the research setting.

- Bioelectric impedance analysis is a body composition assessment that is non-invasive and relatively inexpensive. However, measurements are highly variable, as they are affected by the patient's hydration status.[44]
- CT scan or MRI of the abdomen can be used to accurately measure visceral fat.[45] However, these methods are costly and should only be done in the research setting.

# **Risk factors**

### Strong

### obese parents

• A child's risk of obesity is increased with ≥1 obese parents.[12]

### rapid weight gain in infancy

Rapid weight gain during infancy has been associated with an increased risk of childhood obesity.[19]
 [20]

### weight gain in early childhood

 Children who have a body mass index (BMI) >85th percentile between the ages of 24 and 54 months have a 5-fold greater likelihood of being overweight at age 12 years. In addition, children with a BMI >50th percentile are prone to being overweight by adolescence.[13]

### non-Hispanic black or Mexican-American ethnicity

 Epidemiological studies have shown that children from ethnic minorities have a higher incidence of obesity, especially during adolescence, with Mexican-American boys and girls having the highest prevalence of overweight and obesity. In addition, degrees of physical activity differ between racial groups.[10] [12] [13] [14] [15]

### poor socioeconomic status

• Children raised in poor families have a higher risk of obesity.[26]

### sedentary lifestyle

Children who get less exercise are at higher risk of obesity.[29]

### <u>Weak</u>

### intrauterine growth restriction

• Poor nutrition in utero has been correlated with obesity in childhood and adulthood.[26]

### maternal gestational diabetes

• Fetal hyperglycaemia and hyperinsulinism affects body size at birth and may play a role in later development of obesity.[27]

### poor dietary choices

• Diets high in energy-dense foods, fast foods, and high-sugar beverages have been implicated as a risk factor for the development of obesity in children.[30] However, poor dietary choices alone do not consistently lead to obesity.

### screen time >2-3 hours/day

Obesity risk is increased in children who have daily screen time (e.g., television, video games, internet)
 >2-3 hours per day.[18]

### sleep deprivation

• Epidemiological studies show a link between short sleep time and development of obesity in infants, children, and adolescents.[23] [24] [25]

# History & examination factors

### Key diagnostic factors

### Body mass index (BMI) ≥95th percentile (common)

- Most widely accepted measure of body fat (weight in kilograms divided by height in metres squared).[3]
- · Accurate measurements of both height and weight are important to calculate BMI.
- Abnormal BMI cut-offs in children are determined by age- and gender-specific percentiles based on growth charts.[2]
- Definitions may vary between countries, but a BMI between the 85th and 94th percentile is usually defined as overweight, a BMI ≥95th percentile is defined as obesity, and a BMI >99th percentile is defined as morbid obesity.[3]

### weight ≥95th percentile for height (common)

• For children under 2 years of age, BMI percentiles are not available; thus, obesity may be defined as a weight ≥95th percentile for height.[3]

### Other diagnostic factors

### increased waist-hip ratio (common)

- Can be used as an indirect measure of visceral adiposity (which has been shown to be associated with cardiovascular and metabolic risk factors).[40] [41]
- Waist circumference percentiles have been developed for children aged 2 to 19 years.[2] However, the cut-off values that indicate risk above that of BMI measurement is not available.[14]

### increased skinfold thickness (common)

- Provides information about body fat and the risk of medical complications.[43]
- Difficult to perform accurately, and reference data in children are not readily available; therefore, it is not recommended in the general clinical setting.

### hypertension (common)

• Children who are overweight or obese have a higher prevalence of hypertension; thus, blood pressure should be monitored closely.[38]

# **Diagnostic tests**

# Other tests to consider

Test	Result
<ul> <li>fasting blood glucose</li> <li>To screen for type 2 diabetes mellitus.</li> <li>The American Diabetes Association recommends that children over 10 years of age (or at onset of puberty, if it begins at an earlier age) with a body mass index (BMI) &gt;85th percentile plus 1 or more other risk factors (e.g., family history of type 2 diabetes, non-white race, and/or conditions associated with insulin resistance such as acanthosis nigricans, polycystic ovary syndrome, hypertension, dyslipidaemia, small for gestational age, or maternal history of diabetes or gestational diabetes mellitus during the child's gestation) should have a fasting blood glucose test or a 2 hour plasma glucose during a 75 g oral glucose tolerance test, or haemoglobin A1c every 3 years.[46]</li> </ul>	normal, or impaired glucose tolerance (5.6-6.9 mmol/L [100-125 mg/dL]), or diabetic (≥7 mmol/L [≥126 mg/dL])
<ul> <li>serum lipids</li> <li>To screen for dyslipidaemia.</li> <li>All children should be screened for lipid abnormalities with a nonfasting, non-HDL cholesterol between ages 9 to 11 years and 17 to 21 years.[47]</li> <li>A fasting lipid panel should be obtained in children with a BMI ≥ 85th percentile.[21]</li> <li>Lipid abnormalities in children often persist into adulthood.[47]</li> <li>Cut-off values are as follows.[47] Normal: cholesterol &lt;4.40 mmol/L (&lt;170 mg/dL), LDL &lt;2.85 mmol/L (&lt;110 mg/dL); borderline: cholesterol 4.40 to 5.15 mmol/L (170-199 mg/dL), LDL 2.85 to 3.34 mmol/L (110-129 mg/dL); elevated: cholesterol &gt;5.18 mmol/L (&gt;200 mg/dL), LDL &gt;3.37 mmol/L (&gt;130 mg/dL).</li> </ul>	normal or elevated
<ul> <li>Iver function tests</li> <li>To screen for non-alcoholic fatty liver disease, as most patients will be asymptomatic.</li> <li>Children &gt;10 years of age with a BMI ≥95th percentile, or with a BMI ≥85th percentile and other risk factors, should be screened annually with a serum alanine aminotransferase and aspartate aminotransferase.</li> </ul>	normal or elevated transaminases

# Emerging tests

Test	Result
<ul> <li>DEXA</li> <li>Can be used to assess total body fat.</li> <li>Use of this method is limited by the expense of the method and the inability to distinguish between subcutaneous and visceral fat.</li> <li>It is used mainly in the research setting.</li> </ul>	elevated for age and gender
<ul> <li>bioelectric impedance analysis</li> <li>A non-invasive and relatively inexpensive assessment of body composition. However, measurements are highly variable, as they are affected by the patient's hydration status.[44]</li> </ul>	elevated for age and gender

### Test

#### abdominal CT or MRI

• Can be used to accurately measure visceral fat.[45] However, these methods are costly, and should only be done in the research setting.

### Result

increased visceral fat

# **Differential diagnosis**

Condition	Differentiating signs / symptoms	Differentiating tests
Primary hypothyroidism	<ul> <li>Fatigue.</li> <li>Attenuated growth.</li> <li>Cold intolerance.</li> <li>Constipation.</li> <li>Declining school performance.</li> <li>Dry skin.</li> <li>Coarse hair.</li> <li>Goitre.</li> </ul>	<ul> <li>Free T4 will be low for age.</li> <li>Thyrotropin (TSH) will be elevated for age.</li> </ul>
Secondary hypothyroidism	<ul> <li>Fatigue.</li> <li>Poor growth.</li> <li>Cold intolerance.</li> <li>Constipation.</li> <li>Dry skin.</li> <li>Coarse hair.</li> </ul>	<ul> <li>Free T4 will be low for age.</li> <li>Thyrotropin (TSH) will be low or normal for age.</li> </ul>
Cushing syndrome	<ul> <li>Attenuated growth.</li> <li>Violaceous striae.</li> <li>Buffalo hump.</li> <li>Central adiposity.</li> <li>Moon facies.</li> <li>Hirsutism.</li> <li>Hypertension.</li> <li>Diabetes.</li> </ul>	The 24-hour urinary free cortisol or midnight salivary cortisol is elevated for age.
Prader-Willi syndrome	<ul> <li>Short stature.</li> <li>Small hands and feet.</li> <li>Almond-shaped eyes.</li> <li>Picking on skin.</li> <li>Delayed puberty.</li> <li>Developmental delay.</li> <li>Hyperphagia.</li> <li>History of poor feeding and hypotonia as infant.</li> </ul>	Genetic testing shows imprinting error on chromosome 15q.
Bardet-Biedl syndrome	<ul> <li>Dysmorphic extremities.</li> <li>Retinitis pigmentosa.</li> <li>Developmental delay.</li> <li>Hypogonadism.</li> <li>Renal defects.</li> </ul>	• Mutations in several different genes have been linked to Bardet-Biedl syndrome.[48]

Condition	Differentiating signs / symptoms	Differentiating tests
Pseudohypoparathyroidisn	<ul> <li>Short stature.</li> <li>Round face.</li> <li>Short metacarpals.</li> <li>Developmental delay.</li> <li>Basal ganglia calcification.</li> </ul>	<ul> <li>Serum calcium levels show hypocalcaemia.</li> <li>Serum phosphate levels show hyperphosphataemia.</li> <li>Serum parathyroid hormone level is elevated.</li> </ul>
Monogenic obesity	<ul> <li>Severe, early-onset obesity.</li> <li>Usually associated with disruption of normal appetite control mechanisms.</li> </ul>	<ul> <li>Genetic testing identifies gene mutation in candidate genes such as leptin, ghrelin, adiponectin, peptide YY(3-36), and melanocortin 4 receptor (MC4-R).[49] [50]</li> <li>Mutations in MC4-R are the most common cause in children, occurring in approximately 5% of cases.[51]</li> <li>The obesity gene map database and the National Institutes of Health and Centers for Disease Control and Prevention database of association studies [National Institute on Aging: genetic association database] can be used as a source of candidate genes.</li> </ul>
Hypothalamic obesity	<ul> <li>Severe obesity following treatment for intracranial lesions such as craniopharyngioma.</li> <li>Excessive appetite.</li> </ul>	<ul> <li>Abnormal hypothalamopituitary testing.</li> </ul>
Obesity due to medication	<ul> <li>Several classes of medication can be associated with weight gain, including neuropsychiatric medications and corticosteroids.[14]</li> </ul>	Discontinuation of drug as a therapeutic trial.

# **Diagnostic criteria**

# Body mass index (BMI) percentiles based on age and gender[3]

The following classification may be used in children >2 years of age based on BMI percentiles for specific age and gender:

- Underweight: <5th percentile
- Normal weight: 5th to 84th percentile
- Overweight: 85th to 94th percentile

- Obesity: ≥95th percentile
- Morbid obesity: >99th percentile.

For children under 2 years of age, BMI percentiles are not available; thus, obesity may be defined as a weight  $\geq$ 95th percentile for height.[3]

### Waist circumference

Waist circumference percentiles have been developed for children aged 2 to 19 years.[2] However, the cutoff values that would indicate risk above that of the BMI category in children is not known. In adults, waist circumferences >102 cm for men and >88 cm for women are associated with an increased risk of metabolic problems.[42]

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# Step-by-step treatment approach

Effective treatment strategies for childhood obesity are important, since obese children tend to become obese adults,[12] and they have significant health risks related to the obesity.[14] Treatment modalities include healthy lifestyle modifications (e.g., dietary changes, increases in physical activity, and decreases in sedentary behaviours), medications, and bariatric surgery.[14] [53] [54] [55] There is evidence that more intensive interventions are more effective.[56] The use of medications is reserved for morbidly obese children or obese children with other risk factors. Bariatric surgery is available for morbidly obese adolescents, and the success and complications of this procedure in adolescents is undergoing extensive study. Numerous risk factors associated with cardiovascular disease have been shown to improve among severely obese adolescents undergoing bariatric surgery. Increased weight loss, female sex, and younger age predict a higher probability of resolution of specific cardiovascular risk factors. Clarifying predictors of change in these risk factors may help identify patients and optimise the timing of adolescent bariatric surgery to improve clinical outcomes.[57]

### Lifestyle modification

Lifestyle modification is the initial and main treatment for all children with a body mass index (BMI) ≥85th percentile. It is imperative that the parents and family also adopt healthy lifestyle habits for the child to have success with weight maintenance or weight loss.[58]

Children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Eliminating sugary drinks from the diet has been shown to significantly reduce caloric intake and obesity.[59] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]

Children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to <2 hours daily, as this has been associated with risk of obesity.[18] [64] [65]

As children have the benefit that they are still growing in stature, many children can slim down by maintaining their weight or gaining less weight over time, thus lowering their BMI percentile.

### Counselling

Therapy to modify behaviour is likely to be beneficial along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI after 6 months, or parental obesity is present, more intense counselling is provided for structured weight management.

The effect of family- and parent-based weight loss treatments on child weight loss were compared in a randomised trial of 150 overweight and obese children (8-12 years old) and their parents, over a period of 24 months. Weight loss treatment was delivered in 20 one-hour group meetings with 30-minute individualised behavioural coaching sessions over 6 months, with or without the child present. Parent-based treatment was shown to be non-inferior to family-based weight loss treatment.[68]

### Overweight children (BMI ≥85th to 94th percentile)

All children and their families should be counselled on healthy lifestyle modifications. Children who have remained at the same BMI percentile over several years, and who do not have other medical risks or family history of obesity, may be at low risk of excess body fat, as BMI is only an indirect measure of adiposity. The goal of treatment is weight velocity maintenance (or weight maintenance after linear growth is complete) and close assessment for increasing BMI percentiles or development of other risk factors.

Children with additional risk factors (e.g., family history of type 2 diabetes, non-white race, and/or conditions associated with insulin resistance such as acanthosis nigricans, polycystic ovary syndrome, hypertension, or dyslipidaemia) should receive more intense counselling if there is no improvement in BMI in 6 months, or parental obesity is present, for structured weight management. Some patients may benefit from weight loss not to exceed 0.9 kg per week to eventually bring the BMI below the 85th percentile.

### Obese children (BMI ≥95th to 99th percentile)

All children and their families should be counselled on healthy lifestyle modifications. If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management, and referral for comprehensive multidisciplinary intervention should be considered.

Age 2 to 11 years

• The goal of treatment is weight maintenance or gradual weight loss not to exceed 0.45 kg per month.

Age 12 to 18 years

- The goal of treatment is weight loss not to exceed 0.9 kg per week.
- Children with an inadequate weight response should be referred for tertiary care interventions, which may include medications.[69]
- Orlistat is the only medication currently approved in some countries for children.[70] [71] [72] It inhibits fat absorption through the inhibition of enteric lipase and is approved for children ≥12 years of age (BMI change from -0.55 kg/m<sup>2</sup> up to -4.09 kg/m<sup>2</sup>).[73]Sibutramine was previously approved; however, the European Medicines Agency (EMA) suspended marketing authorisations for sibutramine in the European Union in January 2010 due to safety concerns.[74] It was voluntarily withdrawn by the manufacturer in October 2010, due to clinical trial data indicating an increased risk of heart attack and stroke. Sibutramine may be available in some other countries.
- Although not approved for the treatment of obesity, metformin has been shown to cause weight loss (average BMI change -0.5 kg/m<sup>2</sup>) with relatively few adverse effects.[70] [75] [76] [77] [78] [79] [80] [81]

### Morbidly obese children (BMI >99th percentile)

All children and their families should be counselled on healthy lifestyle modifications. If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management, and referral for comprehensive multidisciplinary intervention should be considered.

Age 2 to 5 years

• The goal of treatment is weight loss not to exceed 0.45 kg per month.

#### Age 6 to 11 years

• The goal of treatment is weight loss not to exceed 0.9 kg per week.

#### Age 12 to 18 years

- The goal of treatment is weight loss not to exceed 0.9 kg per week.
- Children with an inadequate weight response should be referred for tertiary care interventions, which may include medications or bariatric surgery.
- Surgery should only be considered in children who have attained Tanner 4 or 5 pubertal development and final, or near final, height with BMI ≥40 with mild comorbidities, or BMI >35 with extreme comorbidities. Children must be able to adhere to healthy diet and activity to be eligible for surgery.
- The surgical approaches used most often are laparoscopic adjustable gastric banding, the Roux-en-Y gastric bypass, and vertical sleeve gastrectomy. Outcomes of bariatric surgery in the adolescent population are being studied vigorously.[54] [82] [83] [84] [85] [86] [87]
- Surgery reduces caloric intake by either restrictive or malabsorptive mechanisms. Patients must be committed to a lifetime of altered eating habits following surgery.[88]
- There are extensive perioperative risks and post-procedural nutritional risks.
- Surgery should only be performed by an experienced surgeon who works with a team capable of following the patient for long-term metabolic or psychosocial issues.

# Treatment details overview

Consult your local pharmaceutical database for comprehensive drug information including contraindications, drug interactions, and alternative dosing. (see Disclaimer)

Ongoing		( summary )
Patient group	Tx line	Treatment
body mass index (BMI) ≥85th to 94th percentile without other health risks	1st	lifestyle modification + counselling
BMI ≥85th to 94th percentile with other health risks	1st	lifestyle modification + intense counselling
age 2-11 years	1st	lifestyle modification + counselling
age 12-18 years	1st	lifestyle modification + counselling
age 12-18 years	adjunct	pharmacotherapy
age 2-5 years	1st	lifestyle modification + counselling
age 6-11 years	1st	lifestyle modification + counselling

Ongoin	g		( summary )
•••••	age 12-18 years	1st	lifestyle modification + counselling
•••••	age 12-18 years	adjunct	pharmacotherapy
•••••	age 12-18 years	adjunct	surgery

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# **Treatment options**

Ongoing		
Patient group	Tx line	Treatment
body mass index (BMI) ≥85th to 94th	1st	lifestyle modification + counselling
risks		» The goal of treatment is weight velocity maintenance (or weight maintenance after linear growth is complete) and close assessment for increasing BMI percentiles or development of other risk factors.
		» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]
		<ul> <li>Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. The effect of family- and parent-based weight loss treatments on child weight loss were compared in a randomised trial of 150 overweight and obese children (8-12 years old) and their parents, over a period of 24 months. Weight loss treatment was delivered in 20 one-hour group meetings with 30-minute individualised behavioural coaching sessions over 6 months, with or without the child present. Parent-based treatment was shown to be non-inferior to family-based weight loss treatment.[68] Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to &lt;2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]</li> <li>Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy alone with diatary ehappene and increased</li> </ul>
		along with dietary changes and increased exercise.[66] [67]
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1st	<ul> <li>lifestyle modification + intense counselling</li> <li>» The goal of treatment is weight maintenance or gradual weight loss not to exceed 0.9 kg per week to eventually bring the BMI &lt;85th percentile.</li> <li>» Additional risk factors include family history of type 2 diabetes, non-white race, and/or conditions associated with insulin resistance such as acanthosis nigricans, polycystic ovary syndrome, hypertension, or dyslipidaemia.</li> <li>» Diet: children should be encouraged to</li> </ul>
	<ul> <li>The goal of treatment is weight maintenance or gradual weight loss not to exceed 0.9 kg per week to eventually bring the BMI &lt;85th percentile.</li> <li>Additional risk factors include family history of type 2 diabetes, non-white race, and/or conditions associated with insulin resistance such as acanthosis nigricans, polycystic ovary syndrome, hypertension, or dyslipidaemia.</li> <li>Diet: children should be encouraged to aliminate such as acanthosis and be anounaged to</li> </ul>
	<ul> <li>Additional risk factors include family history of type 2 diabetes, non-white race, and/or conditions associated with insulin resistance such as acanthosis nigricans, polycystic ovary syndrome, hypertension, or dyslipidaemia.</li> <li>Diet: children should be encouraged to</li> </ul>
	» Diet: children should be encouraged to
	portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possib unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]
	» Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. The effect of family- and parent-based weight loss treatments on child weight loss were compared in a randomised trial of 150 overweight and obese children (8-12 years old) and their parents, over a period of 24 months. Weight loss treatment we delivered in 20 one-hour group meetings with 30-minute individualised behavioural coaching sessions over 6 months, with or without the ch present. Parent-based treatment was shown to be non-inferior to family-based weight loss treatment.[68] Exercise alone is not as effectiv as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games internet) should be limited to <2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]

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ngoing		
atient group	Tx line	Treatment
		along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided fo structured weight management.
·····∎ age 2-11 years	1st	lifestyle modification + counselling
		» The goal of treatment is weight maintenance or gradual weight loss not to exceed 0.45 kg per month.
		» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]
		<ul> <li>Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to &lt;2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]</li> </ul>
		» Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided fo structured weight management.
·····∎ age 12-18 years	1st	lifestyle modification + counselling
		» The goal of treatment is weight loss not to exceed 0.9 kg per week.
		» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits
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Ongoing					
Patient group	Tx line	Treatment			
		and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]			
		» Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to <2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]			
		» Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management.			
age 12-18 years	adjunct	pharmacotherapy			
		» Orlistat inhibits fat absorption through the inhibition of enteric lipase and has been approved in some countries for children ≥12 years of age.[73] In clinical trials in adolescents, BMI change ranged from -0.55 kg/m <sup>2</sup> up to -4.09 kg/m <sup>2</sup> .[70] Safety and efficacy data are not available beyond 4 years of treatment.			
		<ul> <li>Although not approved for the treatment of obesity, metformin has been shown to cause weight loss (average BMI change -0.5 kg/m<sup>2</sup>) with relatively few adverse effects.[70] [75] [76] [77] [78] [79] [80] [81]</li> </ul>			
		» While sibutramine was previously recommended, the European Medicines Agency (EMA) suspended marketing authorisations for sibutramine in the European Union in January 2010 due to safety concerns.[74]Sibutramine may be available in some other countries.			
		Primary options			

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Ongoing				
Patient	group	Tx line	Treatment	
			» orlistat: 120 mg orally three times daily with each main meal that contains fat	
			OR	
			Secondary options	
			» metformin: 500-2000 mg orally/day given in 2 divided doses	
	age 2-5 years	1st	lifestyle modification + counselling	
			» The goal of treatment is weight loss not to exceed 0.45 kg per month.	
			» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]	
			» Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to <2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]	
			» Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management, and referral for comprehensive multidisciplinary intervention should be considered.	
····· <b>•</b>	age 6-11 years	1st	lifestyle modification + counselling	
			» The goal of treatment is weight loss not to exceed 0.9 kg per week.	

Ongoing		
Patient group	Tx line	Treatment
		» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]
		» Physical activity: children should be encouraged to get at least 60 minutes of physical activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to <2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]
		» Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management, and referral for comprehensive multidisciplinary intervention should be considered.
age 12-18 years	1st	lifestyle modification + counselling
		» The goal of treatment is weight loss not to exceed 0.9 kg per week.
		» Diet: children should be encouraged to eliminate sugar-sweetened beverages, decrease portion sizes, and limit both energy-dense and fast foods.[14] [59] [60] Diets rich in fruits and vegetables should be suggested, and healthy food choices should be offered in the school. Family meals should be encouraged and family involvement is imperative. If possible, unhealthy foods should be removed from the home. Many diets exist, but there is no evidence to recommend one diet over another for children.[54] [61]
		» Physical activity: children should be encouraged to get at least 60 minutes of physical

Ongoing				
Patient group	Tx line	Treatment		
		activity per day.[62] [63] The activity should be age appropriate and fun for the child, to encourage compliance. Family involvement in promoting physical activity is also encouraged. Exercise alone is not as effective as when combined with dietary modifications. Television viewing and other discretionary screen time (e.g., computer and video games, internet) should be limited to <2 hours daily, as they have been associated with risk of obesity.[18] [64] [65]		
		» Counselling: therapy to modify behaviour is likely to be beneficial as an adjunctive therapy along with dietary changes and increased exercise.[66] [67] If there is no improvement in BMI in 6 months, or parental obesity is present, more intense counselling is provided for structured weight management, and referral for comprehensive multidisciplinary intervention should be considered.		
		» If none of these therapies are successful, the child should be referred for tertiary care interventions, which may include pharmacotherapy, or bariatric surgery in older adolescents.		
age 12-18 years	adjunct	pharmacotherapy		
		» Orlistat inhibits fat absorption through the inhibition of enteric lipase, and has been approved in some countries for children ≥12 years of age.[73] In clinical trials in adolescents, BMI change ranged from -0.55 kg/m <sup>2</sup> up to -4.09 kg/m <sup>2</sup> .[70] Safety and efficacy data are not available beyond 4 years of treatment.		
		<ul> <li>Although not approved for the treatment of obesity, metformin has been shown to cause weight loss (average BMI change -0.5 kg/m<sup>2</sup>) with relatively few adverse effects.[70] [75] [76] [77] [78] [79] [80] [81]</li> </ul>		
		<ul> <li>While sibutramine was previously recommended, the European Medicines Agency (EMEA) suspended marketing authorisations for sibutramine in the European Union in January 2010 due to safety concerns.[74]Sibutramine may be available in some other countries.</li> </ul>		
		Primary options		
		» orlistat: 120 mg orally three times daily with each main meal that contains fat		
		OR		

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Ongoin	g		
Patient	group	Tx line	Treatment
			Secondary options
			<ul> <li>» metformin: 500-2000 mg orally/day given in</li> <li>2 divided doses</li> </ul>
••••••	age 12-18 years	adjunct	surgery
			» Bariatric surgery is reserved for the most obese adolescents who have been involved in a behavioural treatment programme for ≥6 months.
			<ul> <li>» It should only be considered in children who have attained Tanner 4 or 5 pubertal development and final, or near final, height with BMI ≥40 with mild comorbidities, or BMI &gt;35 with extreme comorbidities. Children must be able to adhere to healthy diet and activity to be eligible for surgery.</li> </ul>
			» The surgical approaches used most often are laparoscopic adjustable gastric banding, the Roux-en-Y gastric bypass, and vertical sleeve gastrectomy.
			» Outcomes of bariatric surgery in the adolescent population are being studied vigorously.[54] [82] [83] [84] [85] [86] [87]
			» Surgery reduces caloric intake by either restrictive or malabsorptive mechanisms.
			» Patients must be committed to a lifetime of altered eating habits following surgery.[88]
			» There are extensive perioperative risks and post-procedural nutritional risks.
:			

# Emerging

# <u>Cetilistat</u>

An inhibitor of gastrointestinal and pancreatic lipase, similar to orlistat. In obese adults with diabetes, treatment with cetilistat has been found to significantly reduce body weight and improve glycaemic control with fewer adverse effects compared to orlistat.[89]

# Amylin analogues

Amylin is a peptide which is co-secreted with insulin from the pancreatic beta cells and is thought to be important in the regulation of glucose and energy homeostasis. An analogue of amylin is available for the treatment of diabetes in adults and is undergoing clinical trials for the treatment of adult obesity.[90] [91]

# <u>Rimonabant</u>

Rimonabant is a selective cannabinoid 1 receptor blocker shown to be effective in the treatment of adult obesity.[92] However, it has been associated with potentially severe psychiatric adverse effects, including depression and anxiety, and patients may be at increased risk of suicide.[93] Due to these effects, rimonabant has been removed from the market in some countries, including Europe and the UK.

### **Bupropion**

Bupropion is a noradrenaline (norepinephrine) and dopamine reuptake inhibitor used in adults for depression and smoking cessation. It has been studied for treatment of obesity in adults.[90] The combination of extended-release bupropion and the opioid antagonist naltrexone has been investigated.[94] This combination has been approved in the US by the Food and Drug Administration (FDA) for the treatment of obesity in adults.

# <u>Topiramate</u>

Topiramate is an anticonvulsant that induces weight loss. However, adverse effects include depression and difficulties with concentration and memory, which will limit its usefulness in children.[90] A combination of topiramate and phentermine is approved in the US by the FDA for the treatment of obesity in adults.

# <u>Zonisamide</u>

Zonisamide is an anticonvulsant that induces weight loss. It has serotonergic and dopaminergic activity, and also inhibits sodium and calcium channels.[90]

### Exendin 4

Exendin is an incretin mimetic undergoing clinical trials in obese adults. Exenatide, a synthetic version, is used for the treatment of type 2 diabetes in adults. It has been shown to decrease gastric emptying time and decrease food intake in clinical studies.[90] [95] Initial trials in children have shown a reduction in body mass index (BMI) in severely obese children.[96] [97]

# Peptide YY(3-36)

Peptide YY is released by the gastrointestinal tract following a meal and acts by suppressing appetite. Clinical trials with a nasal formulation in adults did not meet the primary endpoints, and thus were stopped. Peptide YY is being studied as a potential therapy in patients who did not lose sufficient weight following bariatric surgery.[98]

### <u>Ghrelin antagonists</u>

Ghrelin is a small peptide secreted from the stomach that is thought to be a signal for meal initiation. Thus, antagonism of ghrelin may be useful to suppress food intake.

### <u>Lorcaserin</u>

Lorcaserin is a highly selective and potent 5-HT2c agonist, which in clinical trials has been found to induce weight loss in obese adults by increasing satiety and decreasing food consumption.[99] [100] Lorcaserin has been approved in the US by the FDA for the treatment of obesity in adults.

### Liraglutide

A glucagon-like-peptide-1 (GLP-1) agonist that has been approved in the US by the FDA for long-term treatment of obesity in adults.[101]

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# Recommendations

# Monitoring

Body mass index (BMI) should be calculated and plotted at each visit to monitor for effects of treatment. Blood pressure should be monitored routinely. The American Diabetes Association recommends that all children >10 years of age with a BMI ≥85th percentile with 2 additional risk factors should have fasting blood glucose level checked every 3 years. Fasting lipoproteins and liver function tests should also be checked routinely. Children should be seen every 4 to 6 months to monitor their weight and provide additional guidance on lifestyle modifications.

# Patient instructions

Lifestyle modification is the first step in the treatment of obesity. The patient should be advised to limit sugar-containing beverages, energy-dense foods, and fast foods, and to decrease portion sizes.[14] [59] [60] Sugared beverages and energy-dense foods should be removed from the home. In addition, the patient should be encouraged to increase their physical activity on a daily basis and limit discretionary screen time (e.g., television, video games, and computer) to <2 hours daily. Family involvement is critical for success in weight maintenance or weight loss. As children are still growing in height, they should concentrate on weight maintenance rather than weight loss (unless they are markedly obese).

[Centers for Disease Control and Prevention: ideas to help children maintain a healthy weight]

# Complications

Complications	Timeframe	Likelihood			
obesity in adults	long term	high			
Approximately 80% of children who are obese at 10 to 15 years	of age will remain obe	se as adults.[12]			
In addition, those children who are already obese at 8 years of age will tend to have more severe obesity and increased morbidity as an adult.[21] [22]					
type 2 diabetes	long term	high			
Risk factors for the development of diabetes in children include a body mass index (BMI) ≥85th percentile, FHx of diabetes, race (e.g., Hispanic or black), and other risk factors such as acanthosis nigricans, polycystic ovary syndrome, or metabolic syndrome. The American Diabetes Association recommends that all children >10 years of age with a BMI ≥85th percentile plus 1 or more additional risk factors should have a fasting blood glucose test, 2 hour plasma glucose during a 75 g oral glucose tolerance test, or haemoglobin A1c every 3 years, or more frequently if BMI is increasing.[46]					
impaired glucose tolerance long term high					
Obese children have a higher prevalence of impaired glucose tol levels.[105] [106]	erance and increased	fasting insulin			
metabolic syndrome	long term	high			

Likelihood

### Complications

A constellation of metabolic derangements including waist circumference >90th percentile for age plus 2 of the following: hypertriglyceridaemia, low high-density lipoprotein (HDL), hypertension, or glucose intolerance.

Timeframe

Higher risk in most obese children.[105]

Treatment is aimed at lifestyle modification and weight loss.

cardiovascular disease	long term	high

Obese children are at risk of developing early aortic and coronary artery fatty streaks and fibrous plaques, [21] [107] [108] and have a higher positive association with early stroke as adults.[109]

hypertension	long term	high			
Systolic blood pressure is significantly increased in obese childre	en and correlates posit	tively with BMI.[38]			
acanthosis nigricans	long term	high			
Associated with high BMI and usually indicative of insulin resista	nce.[110]				
hyperlipidaemia	long term	high			
A fasting lipid panel should be obtained in children with a BMI $\geq 8$	35th percentile.[21]				
All children should be screened for lipid abnormalities with a non-fasting, non-HDL cholesterol between ages 9 to 11 years and 17 to 21 years.[47]					
Lipid abnormalities in children often persist into adulthood.[47]					
Cut-off values are as follows:[47] normal: cholesterol <4.40 mmo (<110 mg/dL); borderline: cholesterol 4.40 to 5.15 mmol/L (170-1 (110-129 mg/dL); elevated: cholesterol >5.18 mmol/L (>200 mg/d	ol/L (<170 mg/dL), LDL 199 mg/dL), LDL 2.85 dL), LDL >3.37 mmol/l	. <2.85 mmol/L to 3.34 mmol/L L (>130 mg/dL).			
post-surgical complications	long term	high			
Complications of gastric banding include improper position of the oesophageal dilatation.	e band, balloon rupture	e, infection, and			
Complications of gastric bypass include infection, iron and vitam bowel or stomach obstruction.	in deficiencies, cholec	ystitis, and small			
Fewer complications are associated with vertical sleeve gastrect anatomy.[87]	omy as there is no rea	rrangement of the			

polycystic ovary syndrome	long term	high

Irregular menses, acne, and hirsutism are associated with polycystic ovary syndrome. Biochemical evidence of hyperandrogenism and polycystic ovaries on ultrasound is usually found.

Treatment strategies include exercise and weight loss, oral contraceptives containing a progestogen with low androgenicity, and insulin-sensitising agents.

Obesity in children		Follow up		
Complications	Timeframe	Likelihood		
obstructive sleep apnoea	long term	medium		
The prevalence of obstructive sleep apnoea is highest in children	n who are severely ob	ese.[111]		
Children may present with a history of snoring with pauses in bre daytime somnolence, poor attention span, and poor academic p	eathing while sleeping erformance.	, restless sleep,		
Tonsillar hypertrophy may be seen on examination. The diagnosis is made by polysomnography, and treatment includes tonsillectomy and adenoidectomy (if indicated) and continuous positive airway pressure (CPAP) during sleep.[112]				
Sleep apnoea may contribute to pulmonary arterial hypertension	l.			
non-alcoholic fatty liver disease	long term	medium		
Children with obesity are at higher risk of developing simple stea cirrhosis.	atosis, steatohepatitis,	fibrosis, and		
Children >10 years of age with a BMI $\geq$ 95th percentile, or with a factors, should be screened annually with liver function tests.	BMI ≥85th percentile	and other risk		
Definitive diagnosis is made with a liver biopsy.				
Treatment is weight loss. Some medications are in clinical trials.	[113] [114]			
psychosocial morbidities	long term	medium		

Overweight children are likely to experience social discrimination and are more likely to become depressed.[115] [116] [117] [118]

Other psychiatric diagnosis can also be present.[119]

cholelithiasis				long tern	า	medium				

More prevalent in overweight and obese children, and can be associated with rapid weight loss.[120]

Children usually present with intermittent, intense, colicky pain in the right upper quadrant of the abdomen.

Diagnosis is made with abdominal ultrasound, and treatment is usually surgical.

intertrigo	long term	medium
Irritation in the folds of the skin.		
Affected areas are typically red and macerated.		
Treatment consists of good hygiene combined with mild emollien necessary.	ts. Topical corticostere	oids can be used as
furunculosis	long term	medium

# Complications

Infection in the folds of the skin.

Treatment consists of proper hygiene, hot moist compresses to facilitate drainage, incision and drainage, and antibiotics as needed.

obesity hypoventilation syndrome	long term	low		
Due to excess adipose tissue on the chest and abdomen.				
Treatment is weight loss and CPAP during sleep.				
slipped capital femoral epiphysis	long term	low		
Typically seen between the ages of 9 and 16 years, and boys are affected more often than girls.[123] Typically presents with hip or knee pain, pain with walking, and decreased range of motion at the hip. Treatment is surgical.				
Blount's disease	long term	low		
A bowing of the lower extremities (i.e., tibia vara), which is typically painless.[123] Radiographical features include changes in the proximal medial tibial metaphysis. Treatment is typically surgical, although orthotic management can be attempted in patients <3 years of age.				
asthma	long term	low		
Obese children have a higher risk of asthma independent of other factors.[125]				
They can present with shortness of breath and poor exercise tolerance.[126] [127]				
constipation	variable	medium		
Can be exacerbated by obesity.[121]				
gastro-oesophageal reflux	variable	medium		

Can be exacerbated by obesity.[122]

pseudotumor cerebri	variable	low	
Children present with severe headaches with photophobia.			
They occasionally have double vision and impairment of cranial nerve VI.			
Blurred optic discs may be noted on examination.[124]			

# Prognosis

Treatment of obesity at any age is a challenge. Even with successful weight loss, children are at risk of rebounding back to or going above their previous weight. Family involvement in the weight loss regimen is

### Timeframe Likelihood

**Follow up** 

# **Diagnostic guidelines**

### **Europe**

#### Obesity: identification, assessment and management

Published by: National Institute for Health and Care Excellence

Summary: Guidelines addressing the identification and assessment of overweight and obesity.

#### Management of obesity

Published by: Scottish Intercollegiate Guidelines Network

### International

### Consensus statement: childhood obesity

Published by: Obesity Consensus Working Group

Summary: An excellent, comprehensive review of childhood obesity provided by an international group of 65 physicians and other health professionals. Covers the prevalence, diagnosis, causes, and risks of childhood obesity.

### North America

### Pediatric obesity - assessment, treatment, and prevention: an Endocrine Society clinical practice guideline

#### Published by: The Endocrine Society

#### Last published: 2017

Summary: A comprehensive review of childhood obesity covering the assessment and prevention of childhood obesity.

### Severe obesity in children and adolescents: identification, associated health risks, and treatment approaches

Published by: American Heart Association

Summary: A comprehensive review of childhood obesity, which covers the diagnosis, causes, and risks of childhood obesity.

### Expert Committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report

Published by: American Medical Association

Summary: A comprehensive review of assessment of obesity in childhood and adolescence.

### Assessment of child and adolescent overweight and obesity

#### Published by: American Academy of Pediatrics

Summary: A comprehensive review of the assessment of an overweight or obese child and adolescent.

Last published: 2010

Last published: 2005

Last published: 2014

Last published: 2013

Last published: 2007

Last published: 2007

# **Treatment guidelines**

### Europe

### **Obesity: identification, assessment and management**

Published by: National Institute for Health and Care Excellence

**Summary:** Includes recommendations regarding lifestyle interventions, behavioural interventions, pharmacological therapy, and bariatric surgery.

### Management of obesity

Published by: Scottish Intercollegiate Guidelines Network

**Summary:** These guidelines provide evidence-based recommendations for the prevention and treatment of obesity within the clinical setting in the UK.

### International

#### Guidelines for surgical treatment of extremely obese adolescents

Published by: International Pediatric Endosurgery Group

Summary: Eligibility criteria to identify appropriate bariatric surgery candidates.

#### **Consensus statement: childhood obesity**

Published by: Obesity Consensus Working Group

**Summary:** An excellent comprehensive review of childhood obesity provided by an international group of 65 physicians and other health professionals. Covers the prevalence, diagnosis, causes, risks, prevention, and treatment of childhood obesity.

### **North America**

# Pediatric obesity - assessment, treatment, and prevention: an Endocrine Society

#### Published by: The Endocrine Society

**Summary:** A comprehensive review of childhood obesity covering the prevention and treatment of childhood obesity.

### Treatment of childhood overweight and obesity

Published by: Michigan Quality Improvement Consortium

#### Prevention and identification of childhood overweight and obesity

Published by: Michigan Quality Improvement Consortium

### **Summary:** Focuses on prevention strategies for overweight and obese children.

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Last published: 2017

Last published: 2016

Last published: 2016

Last published: 2005

Last published: 2009

Last published: 2014

Last published: 2010

### North America

### Canadian 24-hour movement guidelines for children and youth

Published by: Canadian Society for Exercise Physiology

**Summary:** Recommendations for physical activity and sedentary behaviour times (including screen time).

### Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care

Published by: Canadian Task Force on Preventive Health Care

**Summary:** A comprehensive review of recommendations regarding the prevention and management of childhood overweight and obesity.

### 2015-2020 dietary guidelines for Americans

Published by: US Department of Health and Human Services; USLast published: 2015Department of Agriculture

Summary: Provides a comprehensive guide of healthy diet and exercise over various age ranges.

#### Pediatric weight management: evidence-based nutrition practice guideline

Published by: Academy of Nutrition and Dietetics

**Summary:** The focus of this guideline is on the treatment of paediatric overweight and obesity in a multicomponent, multidisciplinary context.

#### Bariatric surgery in obese adolescents: opportunities and challenges

Published by: Cincinnati Children's Hospital Medical Center

**Summary:** Offers an approach to determine which obese children are the best candidates for bariatric surgery, the recommended procedures, the optimal timing of the surgery, and postoperative monitoring and concerns.

# Severe obesity in children and adolescents: identification, associated health risks, and treatment approaches

Published by: American Heart Association

**Summary:** A comprehensive review of childhood obesity, which covers the treatment approaches of childhood obesity.

### Nutritional strategy for adolescents undergoing bariatric surgery

Published by: Nutrition Committee, NASPGHAN/NAHCRI

**Summary:** Recommendations, based on a review of the literature, on how to assess, educate, nourish, and monitor adolescents who have undergone obesity surgery. Produced by the Nutrition Committee for the North American Society of Pediatric Gastroenterology, Hepatology, and Nutrition and National Association of Children's Hospitals and Related Institutions.

### 2008 physical activity guidelines for Americans

#### Published by: US Department of Health and Human Services

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Last published: 2008

Last published: 2014

Last published: 2015

Last published: 2013

Last published: 2011

Last published: 2015

Last published: 2016

### North America

# Recommendations for treatment of child and adolescent overweight and obesity

#### Published by: American Academy of Pediatrics

#### Last published: 2007

**Summary:** A comprehensive review of treatment modalities for paediatric obesity, including dietary interventions, approaches to decrease sedentary activities, behavioural approaches, medications, and bariatric surgery. Provides recommendations for 4 stages of weight management approaches in children: prevention plus, structured weight management, comprehensive multidisciplinary intervention, and tertiary care intervention.

# Expert Committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report

#### Published by: American Medical Association

#### Last published: 2007

**Summary:** A comprehensive review of prevention, assessment, and treatment of obesity in childhood and adolescence.

# 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children

Published by: Obesity Canada Clinical Practice Guidelines Expert Panel Last published: 2007

**Summary:** Evidence-based guidelines produced by multidisciplinary group. Guidelines cover diet, exercise, environment, pharmacotherapy, behavioural therapy, and surgery, and include recommendations for carers as well as highlighting areas for further research.

# **Online resources**

- 1. National Institute on Aging: genetic association database (external link)
- 2. Centers for Disease Control and Prevention: ideas to help children maintain a healthy weight *(external link)*

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# Images

BMI	Dates	2-19 years	2-5 years	6-11 years	12-19 years
≥85 <sup>th</sup> percentile	1999-2000	28.2%	22.0%	29.8%	30.0%
	2003-2006	31.9%	24.4%	33.3%	34.1%
	2007-2008	31.7%	21.2%	35.5%	34.2%
	2009-2010	31.8%	26.5%	32.6%	33.6%
	2011-2012	31.8%	22.8%	34.2%	34.5%
$\geq$ 95 <sup>th</sup> percentile	1999-2000	13.9%	10.3%	15.1%	14.8%
	2003-2006	16.3%	12.4%	17.0%	17.6%
	2007-2008	16.9%	10.4%	19.6%	18.1%
	2009-2010	16.9%	12.1%	18.0%	18.4%
	2011-2014	17.0%	8.9%	17.5%	20.5%

#### Figure 1: Prevalence of overweight and obesity in US children according to age

Adapted from NHANES surveys 1999-2014

BMI	Racial/Ethnic group	Males (2-19 years)	Females (2-19 years)
≥85 <sup>th</sup> percentile	Non-Hispanic white	27.8%	29.2%
	Non-Hispanic black	34.4%	36.1%
	Mexican-American	40.7%	37%
$\geq$ 95 <sup>th</sup> percentile	Non-Hispanic white	12.6%	15.6%
	Non-Hispanic black	19.9%	20.5%
	Mexican-American	24.1%	20.6%

Figure 2: Prevalence of overweight and obesity in US children according to racial/ethnic group and gender

Adapted from NHANES survey 2011-2012



Figure 3: 3T3-L1 adipocytes stained with Oil Red O (ORO). ORO stains lipid droplets red

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