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# A simple guide to classifying body mass index in children

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**Delivered by NOO on behalf of the Public Health Observatories in England**

## **What is the purpose of this paper?**

This paper provides a simple guide to how body mass index (BMI) can be used to assess the weight status of children. It describes the different methods that can be used to interpret BMI in children and young people, explains how the methods differ, and where each method is commonly used.

## **Why do we use BMI?**

- BMI provides a good indicator for levels of body fat. Having a BMI that is either too low or too high is associated with an increased risk of ill health.
- BMI is relatively cheap to obtain and easy to calculate. As a result it is used for population surveys and by health professionals when assessing individual patients.
- BMI is therefore the most frequently used measure for assessing whether adults or children are obese, overweight, underweight, or a healthy weight.

## **Why is BMI classification different for children and adults?**

- The BMI of adults remains relatively constant, regardless of age, unless they gain or lose a lot of weight. When classifying the BMI of adults it is possible to use the same categories (also called thresholds, or cut-offs) for defining underweight, overweight or obesity, regardless of the age and sex of the adult.
- Adults (aged 18 years and above) of all ages are usually classified as obese if their BMI exceeds  $30\text{kg/m}^2$ , or overweight if their BMI is greater than  $25\text{kg/m}^2$ . Individuals with a BMI of less than  $18.5\text{kg/m}^2$  are usually considered underweight.
- Assessing the BMI of children is more complicated than for adults because a child's BMI changes as they mature. Growth patterns differ between boys and girls, so both the age and sex of a child needs to be taken into account when estimating whether BMI is too high or too low.
- Because the relationship between a child's BMI and the level of fatness changes over time, fixed thresholds such as those used for adults should not be applied to children as they would provide misleading findings.

## **How is child BMI classified?**

- Instead of using fixed BMI thresholds to classify individuals (as used for adults) children's BMI is categorised using variable thresholds that take into account the child's age and sex.
- These thresholds are usually derived from a reference population, known as a child growth reference. They are calculated by weighing and measuring a large sample of children to identify how BMI varies by age and sex across the population. As well as showing the pattern of growth, these data also provide an average BMI for a boy or girl at a particular age, and the distribution of measurements above and below this value. This means that individual children can be compared to the reference population and the degree of variation from an expected value can be calculated.

- BMI thresholds are frequently defined in terms of a specific z score\*, or centile, on a child growth reference. Once a child's BMI centile or z score has been calculated, this figure can then be checked to see whether it is above or below the defined thresholds for the child growth reference used.
- There are a number of different child growth references available. The last section of this paper describes these different references, and also describes when and where they are commonly used.
- Each growth reference tends to have a set of recommended thresholds. These thresholds are usually defined by statistical conventions, for example, a whole number of standard deviations from the mean, or a whole number of centiles (such as the 85<sup>th</sup> and 95<sup>th</sup> centiles). One exception is the International Obesity Task Force (IOTF) thresholds which are derived to line up with the adult BMI thresholds for obesity and overweight at age 18 years.

### **What are the different child growth references?**

- Many countries have their own population-specific thresholds for assessing BMI in children. The child growth references that are commonly used in UK and international studies are summarised below.
- In England the British 1990 growth reference (UK90) is recommended for population monitoring and clinical assessment in children aged four years and over. Other BMI thresholds are sometimes used, particularly for international comparison of obesity prevalence.
- It must be noted that data should only be compared when the same threshold has been applied. For example, comparisons should not be made between obesity prevalence calculated using the UK90 growth reference with obesity prevalence calculated using the IOTF thresholds.
- The UK90, IOTF, Centers for Disease Control (CDC) charts and World Health Organization (WHO) charts for ages from 5 to 19 are growth references which provide comparators with the general population, whereas the WHO charts for ages 0 up to 5 are a growth standard and aim to provide an indication of optimal growth.

### **What child BMI references are used in the UK and in international studies?**

The following pages provide a question and answer summary of the most commonly used child BMI thresholds in the UK. For each set of thresholds the reference population is described, and a brief summary given of the methodology and cut-offs used for defining underweight, overweight, and obesity in children.

Examples are given of the main uses of each set of thresholds within the UK and internationally. Links to further information are provided to websites and academic papers.

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\* A BMI z score or standard deviation score indicates how many units (of the standard deviation) a child's BMI is above or below the average BMI value for their age group and sex. For instance, a z score of 1.5 indicates that a child is 1.5 standard deviations above the average value, and a z score of -1.5 indicates a child is 1.5 standard deviations below the average value.

## British 1990 growth reference (UK90)

### 1. What is the size of the reference population and when were the data collected?

The UK90 BMI reference provides centile curves for BMI for British children from birth to 23 years. They are based on a sample of 32,222 measurements from 12 distinct surveys collected between 1978 and 1994. The BMI reference curves are part of the wider British 1990 growth reference which also includes height, weight, head circumference and waist circumference.

### 2. What age range of children/ young people is covered?

0-23 years.

### 3. Where was the reference population sampled from?

UK population only.

### 4. What BMI cut-offs are used?

- Underweight: 2<sup>nd</sup> centile for population monitoring and clinical assessment
- Overweight: 85<sup>th</sup> centile for population monitoring, 91<sup>st</sup> centile for clinical assessment
- Obese: 95<sup>th</sup> centile for population monitoring, 98<sup>th</sup> centile for clinical assessment.

The UK90 BMI reference is available on printed growth charts, where the centiles are shown evenly spaced at 2/3rds of a standard deviation. This means the 0.4th, 2nd, 9th, 25th, 50th, 75th, 91st, 98th and 99.6th centiles are shown.

### 5. How are these thresholds used?

For children aged four years and over:

- Population monitoring thresholds are used for most published obesity and overweight prevalence figures, e.g. those using Health Survey for England and National Child Measurement Programme (NCMP) data;
- Clinical cut-offs are recommended by NICE for use in clinical settings with individual children. Also used for NCMP parental feedback and the NHS choices BMI calculator.

The UK90 thresholds are rarely used outside the UK.

### 6. Where can I find more information?

Charts available to order at: [www.healthforallchildren.co.uk](http://www.healthforallchildren.co.uk)

Published in the Archives of Disease in Childhood: <http://adc.bmj.com/content/73/1/25>

- Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. Archives of Disease in Childhood 1995;73: 25-9.
- Cole TJ, Freeman JV, Preece MA. British 1990 growth reference centiles for weight, height, body mass index and head circumference fitted by maximum penalized likelihood. Statistics in Medicine 1998;17: 407-29.
- Freeman JV, Cole TJ, Chinn S, Jones PRM, White EM, Preece MA. Cross sectional stature and weight reference curves for the UK, 1990. Archives of Disease in Childhood 1995;73: 17-24.

## International Obesity Task Force (IOTF) cut-offs

### 1. What is the size of the reference population and when were the data collected?

These samples include 192,727 children aged 0 to 25 years. Each national data set has over 10,000 subjects, with age ranges covering at least the period from 6 to 18 years. The most recently available survey data from the United States (1988-94) were excluded as data which pre-dated the recent rise in obesity prevalence were preferred.

### 2. What age range of children/ young people is covered?

2-18 years.

### 3. Where was the reference population sampled from?

The IOTF thresholds are derived from body mass index data from six large, nationally representative, cross-sectional surveys from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States.

### 4. What BMI cut-offs are used?

Age and sex specific cut-off points that are extrapolated from the adult BMI cut-offs of 25kg/m<sup>2</sup> and 30kg/m<sup>2</sup> for overweight and obesity respectively. Three grades of thinness are defined from equivalent adult BMIs of 16, 17 and 18.5.

### 5. How are these thresholds used?

The IOTF thresholds are widely used internationally. They are used primarily for making international comparisons or when presenting child overweight and obesity data in academic journals. These thresholds are occasionally used with other data sources, such as data from the Millennium Cohort Study.

### 6. Where can I find more information?

- Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;320: 1240–3.
- Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut-offs to define thinness in children and adolescents: international survey. *BMJ* 2007;335: 194-202.

## World Health Organization (WHO) Child Growth Standard

### 1. What is the size of the reference population and when were the data collected?

The BMI standard is based on a total of 26,985 records with both weight and length (0-24 months) or height (24-71 months), information taken from the Multicentre Growth Reference Study (MGRS) between 1997 and 2003. This study also included a longitudinal follow-up from birth to 24 months and a cross-sectional survey of children aged 18 to 71 months.

Standards are provided by sex and: length/height for age; weight for age; weight for length; weight for height as well as BMI for age.

### 2. What age range of children/ young people is covered?

0-5 years.

### 3. Where was the reference population sampled from?

The WHO Child Growth Standard is based on an international sample from Brazil, Ghana, India, Norway, Oman and the United States.

### 4. What BMI cut-offs are used?

WHO suggest a set of thresholds based on single standard deviation spacing (i.e. +1 SD, +2 SD etc).

However on the WHO / UK90 child growth charts (for use with children aged under four years), the 91<sup>st</sup> and 98<sup>th</sup> centiles are shown for classifying individual children as overweight or obese. For population monitoring in this age group the 85<sup>th</sup> and 95<sup>th</sup> centiles of the WHO reference are used.

### 5. How are these thresholds used?

The WHO Child Growth Standard is used internationally, although IOTF is more widely used.

Growth Standards for 0-4 years are recommended for use in the UK.

### 6. Where can I find more information?

[www.who.int/childgrowth/standards/](http://www.who.int/childgrowth/standards/)  
[www.bmj.com/content/340/bmj.c1140](http://www.bmj.com/content/340/bmj.c1140)  
[www.who.int/childgrowth/mgrs/en/](http://www.who.int/childgrowth/mgrs/en/)

## World Health Organization (WHO) 2007 growth reference

### 1. What is the size of the reference population, and when were the data collected?

The WHO 2007 growth reference was developed using the same method as used for the WHO Growth Standards, but merging data from the cross-sectional component of the WHO Multicentre Growth Reference Study (MGRS) (for children aged 18-71 months) with data used for the earlier National Center for Health Statistics (NCHS)/WHO growth reference (children aged 1-24 years).

The NCHS/WHO reference was based on a sample of children of European ancestry in the United States, collected during the 1960s and 1970s.

The 2007 reference is available for both height and weight for age as well as for BMI. The WHO 2007 reference almost perfectly aligns with the WHO Child Growth Standards at age five years.

### 2. What age range of children/ young people is covered?

5-19 years.

### 3. Where was the reference population sampled from?

The WHO 2007 growth reference was derived from a combination of the USA National Centre for Health Statistics 1977 pooled growth data, and the WHO Multi-centre Growth Reference Study (MGRS) from Brazil, Ghana, Norway, India, Oman, USA.

### 4. What BMI cut-offs are used?

WHO suggest a set of thresholds based on single standard deviation spacing.

- Thinness: <-2SD
- Overweight: between +1SD and <+2SD
- Obese: >+2SD

### 5. How are these thresholds used?

The WHO 2007 growth reference is used internationally, although the IOTF thresholds are more widely used.

### 6. Where can I find more information?

[www.who.int/growthref/en/](http://www.who.int/growthref/en/)

[www.who.int/childgrowth/mgrs/en/](http://www.who.int/childgrowth/mgrs/en/)

- WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards Acta Paediatrica Supplement 2006;450
- de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bulletin of the World Health Organization, 2007;85(9): 649-732.
- Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht<sup>2</sup>) and triceps skinfold thickness. American Journal of Clinical Nutrition 1991;53: 839-46.



## United States Centers for Disease Control and prevention (CDC) 2000 growth reference

**1. What is the size of the reference population and when were the data collected?**

The CDC 2000 growth reference was developed using five national health examination surveys (the National Health Examination Survey (NHES) and the National Health and Nutrition Examination Survey (NHANES)) for girls and boys. Some limited supplementary information was collected from vital statistics on child birth weight, length, and head circumference sourced from birth certificates and hospital records (1963-1995).

**2. What age range of children/ young people is covered?**

2-20 years.

**3. Where was the reference population sampled from?**

USA population only.

**4. What cut-offs are used?**

The CDC 2000 growth reference defines children as at risk of overweight and obesity if their BMI exceeds the 85th and 95th centiles for most routine assessment. The 90th and 97th centiles are used for special health care requirements. The third and fifth centiles are used to define underweight status.

**5. How are these thresholds used?**

The CDC 2000 growth reference is primarily used in the United States.

**6. Where can I find more information?**

[www.cdc.gov/nchs/data/series/sr\\_11/sr11\\_246.pdf](http://www.cdc.gov/nchs/data/series/sr_11/sr11_246.pdf)

[www.cdc.gov/growthcharts/cdc\\_charts.htm](http://www.cdc.gov/growthcharts/cdc_charts.htm)

## Reader Information

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