

Consideration of issues around the use of BMI centile thresholds for defining underweight, overweight and obesity in children aged 2-18 years in the UK

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Background

1. In 2007, the Scientific Advisory Committee on Nutrition (SACN) and the Royal College of Paediatrics and Child Health (RCPCH) successfully collaborated to form an Expert Group to discuss the WHO Growth Standards for children in the UK. In 2009, the Department of Health asked the Joint SACN/RCPCH Expert Group to reconvene and provide advice on the use of Body Mass Index (BMI) centile thresholds for defining underweight, overweight and obesity in children aged 2-18 years in the UK. The advice was sought to address confusion surrounding various sets of BMI thresholds currently in use to define overweight and obesity and the consequent inconsistency in reports of the prevalence of overweight and obesity. The SACN/RCPCH Expert Group were asked to provide their judgement on the best way forward.
2. In 2007, the National Obesity Observatory (NOO) for England, commissioned by the Department of Health to support the cross-government strategy 'Healthy Weight, Healthy Lives' (HWHL), was asked to review the options for defining overweight and obesity for population surveillance in children aged 2-18 years in the UK. Their report outlining the various thresholds currently applied was considered by SACN/RCPCH.
3. BMI is the most frequently used measure for child obesity prevalence in the UK. Children are usually classified as overweight or obese by comparing their BMI with a reference population that describes the distribution of BMI within a population by both age and sex. This is necessary because a child's BMI changes with age and sex so fixed thresholds, as applied to adults (30 and 25 kg/m²), cannot be used.

4. There are a number of published thresholds and reference populations to which a child's BMI can be compared. The lack of coherence has given rise to confusion and lack of consistency in the reporting of overweight and obesity. In particular, comparisons across countries have been approached inconsistently, and discrepancies are evident between adult and child BMI thresholds. Therefore, there is the need to consider the issues surrounding the possibility of using a single set of thresholds.
5. The options outlined by NOO, and considered by SACN/RCPCCH were as follows:

- a. *International Obesity Taskforce (IOTF) thresholds*

The IOTF has recommended thresholds for obesity and overweight; these are based on the average values over a number of different reference populations^a and provide a set of thresholds by age and sex that can be used to determine which children are overweight or obese (Cole *et al.*, 2000). The IOTF thresholds are not provided as part of a BMI growth reference, and can only be used to classify children into healthy weight/overweight/obese categories.

The IOTF BMI thresholds for children are aligned, as can best be estimated, to the obesity and overweight thresholds used for adults (30 and 25 kg/m²).

- b. *WHO 2007 growth reference for 5-19 years*

In 2007 the World Health Organization (WHO) published a growth reference for BMI for children aged 5-19 years (de Onis *et al.*, 2007), which complements the 2006 Growth Standards^b for children aged 0-5 years. The WHO 2007 reference for children aged 5-19 years is derived from US survey data collected between 1963 and 1974. To compensate for a potential positive skew in bodyweight, 3% of records were excluded on the basis of unhealthy weight-for-age, using the same cleaning rules as applied when producing the WHO 2006 Growth Standards. Thresholds for obesity and overweight have been recommended for the 2007 growth reference that closely match with the adult thresholds at age 19 years.

The WHO provide a full growth reference (rather than a set of recommended thresholds like the IOTF), which can be used to calculate the relative position of individual children for height, weight and BMI, rather than just classifying individuals as obese, overweight or healthy weight.

^a A growth reference simply describes the growth of a sample of individuals without making any association with health.

^b A growth standard describes the growth of a 'healthy' population and suggests an aspirational goal or target.

c. UK1990 population thresholds (85th and 95th centiles)

Currently, most published prevalence figures in the UK for child obesity are based on the population surveillance thresholds of 85th and 95th centiles of the UK1990 growth reference. These thresholds are arbitrary and are based on the assumption that around 15% of the baseline population are overweight and 5% obese. The UK1990 BMI reference provides centile curves for BMI for British children from birth to 23 years, based on a sample of 32,222 measurements from 12 distinct surveys collected between 1978 and 1994, most of which were nationally representative (Cole *et al.*, 1990). The BMI reference curves are part of the wider UK 1990 growth reference, which also includes height, weight, head circumference and waist circumference.

d. UK1990 clinical thresholds (91st and 98th centiles)

In clinical settings within the UK, the 91st and 98th centiles of the UK1990 reference are generally used to classify children as overweight and obese and in need of clinical intervention. These thresholds are marked on the child growth charts and used by a variety of health professionals to assess individual children. However, a diagnosis of obesity or overweight would rarely be made on BMI measures alone; for example, physical examinations and other anthropometric measures may be used.

e. UK1990 centiles adjusted to align with adult BMI thresholds

This option is not currently available for use, but describes the possibility to develop thresholds based on a UK dataset that aligns with adult overweight and obesity BMI thresholds at a given age. This might be age 18 years or possibly later because adult BMI is only reached after the age of 18 years. Such an approach would require the development of a new centile chart.

6. NOO used data on BMI in children from the National Child Measurement Programme (which measures height and weight of children in reception and year 6 in England) dataset to illustrate the impact on prevalence figures for children when applying different thresholds. This dataset was used as an example because it was regarded as the most comprehensive dataset to allow comparisons and inform discussion.
7. Advantages and disadvantages of each of the options were identified by NOO. A summary of advantages and disadvantages of the potential thresholds for obesity and overweight prevalence in the UK are tabulated in Annex 1.

SACN/RCPCH's considerations regarding use of thresholds for surveillance

BMI thresholds for overweight and obesity

8. The Committee dismissed the possibility of developing UK1990 centiles adjusted to align with adult BMI thresholds (option e), at an early stage in discussions, largely because of the requirement for long-term data concerning health risk in adulthood, which is currently not available. Instead, focus remained on the attributes of existing approaches.
9. The WHO 2007 growth reference for 5-19 years (option b) was considered to be inappropriate for population monitoring in the UK. The Committee considered data used to derive the reference population as not robust. The reference population is derived from US survey data collected between 1963 and 1974 and is therefore neither internationally representative nor representative of the UK, and may even represent a positive skew in bodyweight (as the US population has a high prevalence of obesity).
10. The IOTF BMI thresholds for children (option a) are aligned to the obesity and overweight thresholds used for adults and therefore these thresholds best address the discontinuity at aged 18 years on transition to adult thresholds. However, it could be argued that the use of adult BMI thresholds at age 18 years is too early in the lifespan as adult BMI is only reached after the age of 18 years. The Committee identified that a major disadvantage of the IOTF thresholds is that it can only be used to categorise an individual child as being either obese or overweight but does not constitute a full growth reference for children.
11. As a result, the Committee focussed attention on the two approaches using the UK1990 BMI reference: population thresholds (85th and 95th centiles) and clinical thresholds (91st and 98th centiles).
12. The Committee recognised that the population and clinical BMI centile thresholds currently applied to define overweight and obesity in children are a historical precedent, and there appeared to be no obvious scientific rationale for their use. Each threshold was selected pragmatically to serve a specific purpose in the varying contexts of clinical management or surveillance. The UK1990 85th and 95th centiles are exact centile values used to estimate population prevalence of overweight and obesity. The UK1990 91st and 98th centiles are rounded centile values of 90.9 and 97.7 corresponding to SD scores of +1.33 and +2.00 SDs respectively; they appear as major centile lines as part of the nine centile chart format used on all UK growth charts and are commonly used to define overweight and obesity in clinical settings. These two sets of thresholds identify a different number of overweight and obese individuals. The UK1990 85th and 95th centiles have been recommended for use in surveillance to report prevalence of overweight and obesity. However, there is considerable confusion over the utility of other approaches, particularly when reporting local data. The situation is further complicated by the common use of IOTF thresholds internationally and in individual research studies which again yield different prevalence rates. See figure in Annex 2 for an example of a comparison of prevalence figures of overweight and obesity in English children using a range of thresholds.

13. Obesity is defined as ‘*a condition of excess body fat to the extent that it may have an adverse effect on health*’ so ideally BMI centile thresholds would be based on scientific evidence of a link between specific BMI centile values in children and short- and long-term health risks. Although evidence suggests that higher BMI values in childhood are associated with adverse short- and long-term health effects (Reilly *et al.*, 2003), there are currently no data available to demonstrate a link with a specific BMI value. There is therefore no *a priori* reason for selecting one particular set of thresholds as preferable over another for all circumstances. As a result, a pragmatic approach is required.
14. Since each threshold has a particular, discrete, purpose, disregarding any in the short term would be problematic and could adversely influence surveillance or clinical decision making. It is important to recognise that no single threshold fulfils all functions sufficiently. For example, retaining the 91st/98th centiles only and disregarding the 85th/95th centiles (so using 91st/98th for both clinical and population surveillance) could adversely impact on planning for universal and local obesity prevention strategies because the choice of higher thresholds might not adequately capture those potentially at risk of overweight or obesity. Retaining only the 85th/95th thresholds and disregarding 91st/98th thresholds would result in more children being identified for clinical intervention than is necessary. Also, the 85th/95th thresholds do not appear on standard growth charts used in clinical practice as they are used for population surveillance.

BMI thresholds for underweight

15. Alongside the discussion on BMI centile thresholds to define overweight and obesity in children, the Committee was also asked to take the opportunity to consider appropriate BMI centile thresholds for defining underweight in children. A set of thresholds for underweight or thinness has been developed using a similar methodology to that used for the overweight/obesity thresholds (aligned with adult thresholds for thinness grades 1, 2 and 3 and passing through BMI values of 18.5, 17 and 16 kg/m² at age 18) (Cole *et al.*, 2007). However, the Committee again focussed on approaches using the UK1990 BMI reference.
16. Although there is at present no formal definition for calculation of prevalence of underweight, the 2nd and 0.4th centiles are marked on the current UK 1990 BMI charts. They have been used in clinical settings to indicate underweight among children over 2 years of age. The 2nd and 0.4th centiles are rounded centile values of 2.3 and 0.38 corresponding to underlying SD scores of -2.00 and -2.67 SDs respectively. BMI thresholds for underweight have not led to confusion in reporting as they have done for overweight and obesity because the same thresholds are applied in both population surveillance and clinical management. See figure in Annex 2 for prevalence figures of underweight in England.

Recommendations

17. Following two meetings of the Joint SACN/RCPCH Expert Group in September 2009 and April 2010, members agreed that the purpose, use and interpretation of thresholds should be clarified, and clear guidance on the language used for reporting prevalence data is critical. Although it was agreed that a single system would be preferable, there was no consensus over a single option because clinical and surveillance needs are distinct.

BMI thresholds for overweight and obesity in children 4-18 years of age in the UK, using UK1990 reference charts

18. The Committee recommends that the four UK1990 reference thresholds (i.e. 85th and 95th for surveillance and 91st and 98th for clinical use) continue to be used together within the UK with the language used to describe each one and the purpose of each threshold carefully defined for a limited period of two years. Further guidance on the application of each threshold would be useful to ensure consistency in thresholds used for reporting.

19. The Committee has suggested the following descriptors for testing:

Purpose	Clinical management and planning individual-based interventions			Population surveillance and planning population-based interventions		
	Centile	Current descriptor	Revised descriptor	Centile	Current descriptor	Revised descriptor
Thresholds	91st	Overweight	Overweight	85th	Overweight	At high risk of overweight
	98th	Obesity	Clinical obesity	95th	Obesity	At high risk of obesity

20. To avoid further confusion in the field and amongst the public, the Committee recommends that the Department of Health should consider testing the suggested descriptors before they are applied. The testing should explore any practical issues associated with using the descriptors for population surveillance and clinical practice before their use.

21. It is desirable to move towards a single set of values for BMI thresholds and it is reasonable that this objective be achieved within 2 years. Government should formally review the situation within 2 years, taking into account any further evidence which could help identify short and longer term health risks associated with any specific BMI values.

22. The Committee recognises the importance of making international comparisons of obesity and overweight prevalence. The Committee has noted that, although direct comparisons cannot be made using the UK1990 thresholds (suitable for population surveillance), the 91st centile does however closely match the International Obesity Task Force (IOTF) threshold and appropriate analysis could be undertaken in order to make international comparisons.

23. SACN/RCPCH has agreed that it is not useful to define any further threshold to identify morbidly obese children.

BMI thresholds for underweight in children 4-18 years of age in the UK, using UK1990 reference charts

24. The Committee suggests that descriptors for thresholds for underweight in children over 2-years of age be defined as follows:

Centile	Descriptor	Purpose
0.4 th	Very thin	For clinical management employing appropriate intervention
2 nd	Low BMI	For clinical assessment For population monitoring of underweight prevalence

Application of defined thresholds for children aged 2-4 years

25. New UK-WHO growth charts have been introduced for infants aged 0-4 years. SACN/RCPCH have considered whether their recommended approach on BMI thresholds for children aged 4-18 years (outlined above) can be used for children aged 2-4 years using the UK-WHO growth charts (height and weight are used instead of BMI for infants below age 2 years). The new UK-WHO charts have been developed mainly for use by clinicians in assessing individual babies and therefore have lines drawn at 91st and 98th centiles. Although the full range of centiles (including the 85th and 95th centiles) are not marked out on the new charts, the 85th/95th centiles could still be used as thresholds for population surveillance for this age group since these thresholds can be readily calculated from the UK-WHO data. The Committee recognised there would be a disjunction at 4 years on transfer from the UK-WHO chart to the UK1990 chart with any approach used, but agreed that there is currently no rationale not to apply the same thresholds for surveillance as for the 4-18 year group.

Recommendations for future research

26. The Committee has noted the lack of scientific evidence on the relationship between each of the upper bound BMI thresholds and any potential short- and long-term health risks for the child. The Committee therefore recommends that such evidence be pursued in future research. If such evidence becomes available during the trial period then it could be used to inform the position on BMI thresholds for overweight and obesity in two years time.
27. The recommendations presented here do not overcome the problem of discontinuity with adult thresholds at age 18. Therefore, it remains impossible to compare directly the prevalence of overweight and obesity prevalence in child and adult groups of the population. Further longitudinal data on change in BMI with age would be required in order to calculate centiles illustrating continuity across the child-adult transition. Therefore, it is recommended that researchers conduct prospective studies to clarify how obesity and overweight track from childhood into adulthood.

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Annex 1: Summary of advantages and disadvantages of potential thresholds for obesity and overweight prevalence in the UK

Name	Description	Advantages	Disadvantages
UK1990 population thresholds (85 th and 95 th centiles) (currently used)	For population monitoring purposes the 85 th and 95 th centile of the UK1990 Growth Reference are currently used to classify children as overweight or obese according to their BMI. They are the most frequently used thresholds for published obesity and overweight prevalence figures for children in England.	<ul style="list-style-type: none"> • Would ensure consistency with previously published figures and increase potential for analysis • Provides a full growth reference so that not only can the BMI centile position of all individual children be calculated, but similar assessments can be made for height, weight and other anthropometric measures 	<ul style="list-style-type: none"> • Thresholds have been set arbitrarily without particular scientific rationale • Thresholds only seek to identify at risk groups within the child population. A lower proportion of children would be diagnosed as obese or overweight in a clinical setting • Not comparable with adult prevalence figures • Does not allow international comparisons
UK1990 clinical thresholds (91 st and 98 th centiles)	In a clinical setting (in England), the 91 st and 98 th centile of the UK1990 Growth Reference are used to classify children as overweight and obese. These are marked on the child growth charts and used by a variety of health professionals.	<ul style="list-style-type: none"> • Would tackle the issue of published prevalence figures being very different from the proportion of children diagnosed as obese or overweight and might result in a small reduction in the number of conflicting definitions used for production of prevalence figures (although these are rarely used to calculate prevalence) • Would bring the cut-offs for obese and overweight closer to those used for adults • Although arbitrary, these were chosen based on a spacing of 2/3rds standard deviations from the mean rather than any link to adult BMI or future health problems • They have been in regular use by clinicians for some time, suggesting that these thresholds function as an acceptable diagnostic tool 	<ul style="list-style-type: none"> • Would not assist in ensuring prevalence figures were internationally comparable or comparable with those published for adults • There are some access problems around the reference data for regional and local health organisations, which could obstruct wider usage • Does not allow international comparisons • Prevalence figures are currently published infrequently using the UK1990 clinical thresholds, so might add to rather than reduce the number of thresholds currently being used with UK data
UK1990 centiles that align with adult BMI	Potential to develop thresholds based on the UK dataset that align with the cut-offs for adult overweight	<ul style="list-style-type: none"> • Would provide a set of UK-derived thresholds that provide prevalence figures, which would be comparable with those produced for adults 	<ul style="list-style-type: none"> • Would not provide internationally comparable figures, although could be argued that these figures would provide something close to a 'national

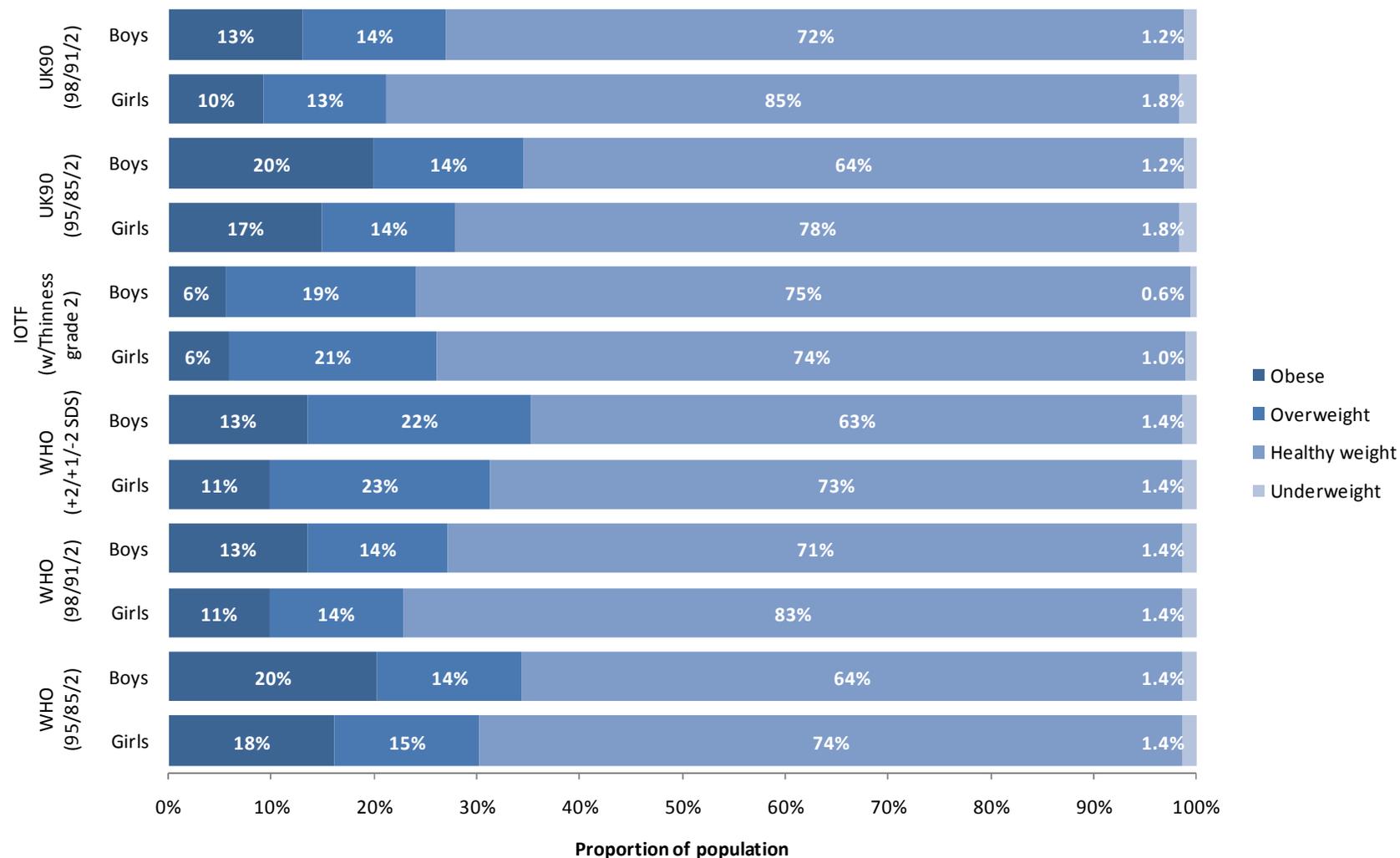
Name	Description	Advantages	Disadvantages
thresholds	<p>and obesity at a given age. This might be at age 18, or possibly a later age as adult BMI is only reached after age 18; for example, where this has already been done with the UK1990 reference, the thresholds were established to line up with the adult cut-offs at age 19.5 for both sexes.¹</p> <p>Although prevalence figures have occasionally been published using such an approach this would require a new set of thresholds to be established which would need to be reviewed and accepted by health professionals before they became widely used.</p>	<ul style="list-style-type: none"> The thresholds produced would be fairly close to the IOTF and WHO thresholds at least for older children, as these also align with the adult thresholds. The degree to which this would be the case would depend on the methodology used 	<p>equivalent' of the IOTF method and so potentially could be compared to prevalence figures for other countries which had taken a similar approach</p> <ul style="list-style-type: none"> Would add to the number of possible thresholds used for published prevalence figures rather than reduce this number
International Obesity Taskforce (IOTF) thresholds	<p>The IOTF has recommended a set of thresholds, which can be used to define individual children as obese and overweight. They are based on an international sample and are linked to the adult cut-offs at age 18. They provide a set of cut-offs by age and sex, which can be used to determine which children are obese or overweight. They are not provided as part of a BMI growth reference, which could be used to calculate a centile for the BMI of all children, and can only be used to</p>	<ul style="list-style-type: none"> Based on the rationale that the thresholds for childhood obesity and overweight should be consistent with the BMI thresholds used for those aged 18 and over Aligned with adult cut-offs at age 18. Prevalence figures for children could be directly compared to the prevalence in the adult population They are the most frequently used in the UK (after the UK1990) for calculation of prevalence figures, so adoption of these might ensure more consistency between published prevalence figures Currently the most used internationally and are based on a sample of children from more than one ethnic group, which makes them a good choice of threshold 	<ul style="list-style-type: none"> Can only be used to categorise an individual child as being either obese or overweight, whereas full growth references (such as the UK1990 reference or WHO standards) can be used to calculate the BMI centile for age for all children in a dataset Some studies have recommended change in BMI centile or z score to be used as an indicator of change in adiposity both for populations and at an individual level, but such analysis is not possible with the IOTF thresholds Cannot calculate centiles for height and weight measures as well as for BMI (unlike UK1990 and WHO datasets), which prevents more detailed analysis of their changing distributions in the

Name	Description	Advantages	Disadvantages
	<p>classify children into the categories of healthy weight, overweight and obese.</p> <p>Since being published in 2000 they have been widely used around the world and are currently one of the most frequently used set of thresholds.</p>	<p>when considering international comparisons</p> <ul style="list-style-type: none"> • Freely available so could be used by the NHS without restrictions 	<p>population</p> <ul style="list-style-type: none"> • Although IOTF methodology lines up with the adult BMI thresholds at age 18, children's BMI is thought to increase beyond this point. IOTF thresholds may assume adult BMI is reached too soon. • The IOTF thresholds have been criticised for apparent low sensitivity i.e. their ability to identify obese children as such, although this is balanced by high specificity.
<p>WHO 2007 growth reference for 5-18 years</p>	<p>In 2007 the WHO published a growth reference for BMI for children aged 5-19 years. This reference complements the 2006 Growth Standards for children aged 0-5 years and can be used together to provide obesity and overweight thresholds from 2 to 18 years.</p> <p>The 5-18yrs reference is derived from US survey data collected between 1963 and 1974 and so may not describe optimal growth given the extent of its positive skewness in body weight. To compensate for this, 3% of records were excluded on the basis of unhealthy weight-for-age, using the same cleaning rules as applied when producing the WHO 2006 Growth Standards. The dataset was adjusted to make it more consistent</p>	<ul style="list-style-type: none"> • Thresholds of +1 SD and +2 SD (i.e. the 84.1st and 97.7th centiles) have been recommended as obesity and overweight thresholds when using the WHO 2007 growth reference (because these match the adult thresholds at age 19) • Based on a similar rationale to the IOTF cut-offs but match the adult cut-offs at age 19 and would therefore produce prevalence figures for children that are statistically consistent with those produced for the adult population • The 2007 WHO thresholds align closely to the adult cut-offs at age. As most growth references show BMI is still rising at age 18, aligning the cut-offs at this later age may be more appropriate. • Although few prevalence figures have been published to date using this new definition, it has been developed to be used internationally. It will be used, for example, to produce prevalence figures for the WHO European Child Obesity Surveillance Initiative (WHO COSI). In future it would therefore be possible to make international comparisons if used • The WHO reference data are freely available and 	<ul style="list-style-type: none"> • Although WHO growth standards for 0-5 are based on a robust methodology and carefully selected international sample, the reference for 5-19 years is arguably less robust • The validity of using pre-1977 population data from the US as the basis of the WHO 2007 reference is questionable. This sample cannot be considered truly internationally representative, as it is based on data from only one country. In addition, as the US is thought to be one of the most obese populations in the world, the population might be considered inappropriate to use as a global reference, even from as early as 1977. • Although WHO has cleaned and adjusted the dataset to account for this issue, it is likely the WHO 2007 reference would be more robust had it been based on a similar dataset to that used for the 2006 Growth Standards • Being a new growth reference, there is little published information that uses this definition (although within the next year current prevalence figures for child obesity using this definition should

Name	Description	Advantages	Disadvantages
	<p>with the more recent international sample used for the 0-5 WHO standard.</p> <p>Thresholds for obesity and overweight have been recommended for the 2007 growth reference that matches closely with the adult thresholds at age 19. The WHO reference has recently been published and so there are limited examples of its use to date to calculate prevalence figures. However, this reference will be adopted for prevalence figures published by the WHO and so it is anticipated its use will increase amongst other organisations.</p>	<p>data are available for height, weight and BMI, rather than BMI alone</p> <ul style="list-style-type: none"> • Like the UK1990 dataset, the WHO 2007 provide a full growth reference, rather than a set of recommended cut-off points, which can be used to calculate the relative position of individual children for all three measurements rather than just classing individuals as obese, overweight or healthy weight • Supporting software is available free of charge to allow analysis both at individual child and population level • WHO Growth Standards have now been adopted in England for ages 2 weeks to 4 years, so using the WHO 2007 BMI thresholds for 2-18 years would be consistent with this development 	<p>be published for fifteen European countries as a result of the WHO COSI)</p> <ul style="list-style-type: none"> • In order to compare with these figures current prevalence figures will need to be recalculated based on the WHO thresholds even if they are not adopted routinely • The previous 1995 WHO thresholds were reasonably well used, despite being based entirely on US data from a population already known to have high levels of obesity and overweight prevalence. The 2007 thresholds have more of an international basis, as a result of being aligned with the international WHO Growth Standards for ages 0-5 years, and refer back to the 1977 US data rather than the more recent 1995 sample. It is therefore possible that these thresholds will gain wider acceptance than their predecessors

Annex 2: Prevalence of underweight, overweight and obesity in England 2008/09 using different thresholds; National Child Measurement Programme data

Year 6 (children aged 10-11 years)



This document had been prepared for consideration by the Scientific Advisory Committee on Nutrition. It does not necessarily represent the final views of the Group or the policy of Health Departments and the Food Standards Agency.

Reception year (children aged 4-5 years)

