What makes a good growth chart? *The UK experience*

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RCPCH growth charts group

Why does chart design matter?

- Growth charts are complex clinical tools that can mislead as well as inform
- Format will influence screening thresholds and wide range of clinical decisions and judgements
- In UK are issued to >500,000 parents every year

Royal College of Child Health (RCPCH) and growth charts

2008 RCPCH commissioned by DH to design new pre school charts

2009 Implementation in England, supporting educational materials, train the trainer sessions

2010 Adopted by Scotland, New Zealand, Eire
Work on school age charts begins, educational materials revised, papers written

2012 School age charts published

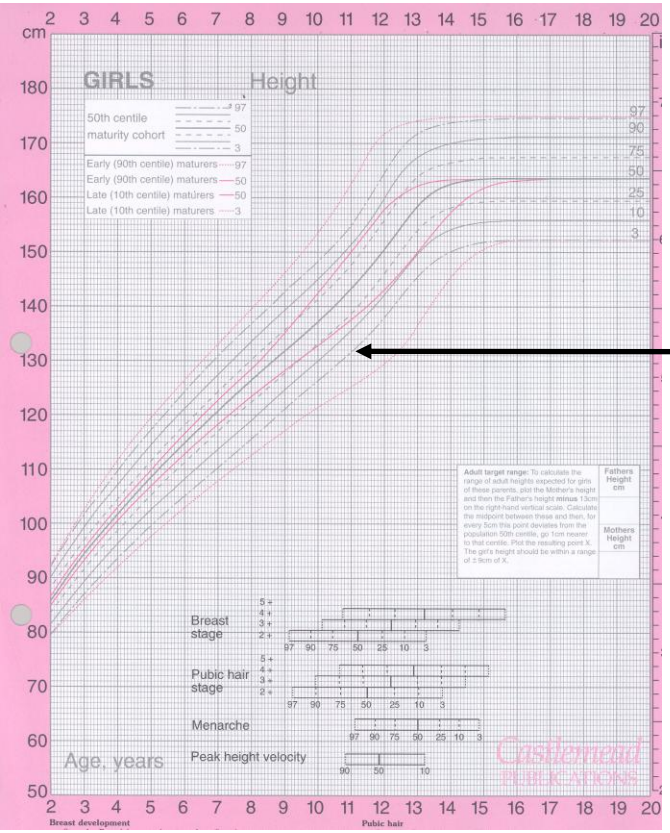
So what makes a good growth chart?

- Must be appropriate for proposed use
- Clear, effective layout
- Good, well evidenced instructions
- Simplicity
- Evaluation and consultation

Must be appropriate for proposed use e.g. UK-WHO Pre-school chart

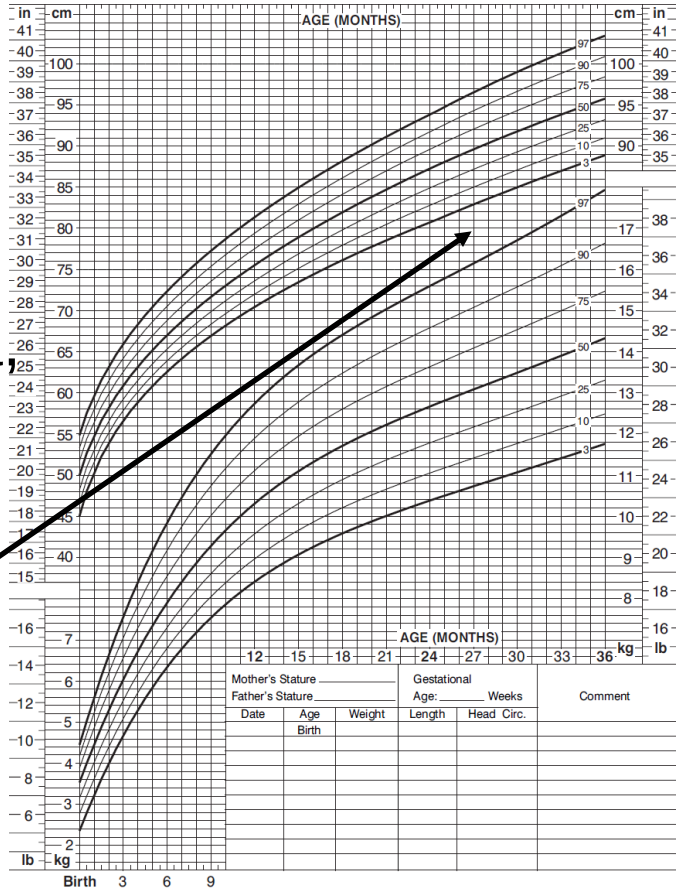
- Who are main users?
  - Children aged 32 weeks gestation to 4 years
  - Public Health nurses, family practitioners
- What are these charts for?
  - Screening, monitoring
- Who will measure what and when?
  - Weight, Height/ length: sometimes
  - Head circumference: in early weeks only
  - BMI: after age of 2 years

Find the right layout



Poor use of space, limited plotting area, lots of blank space

No waste of space, but weight and length too close



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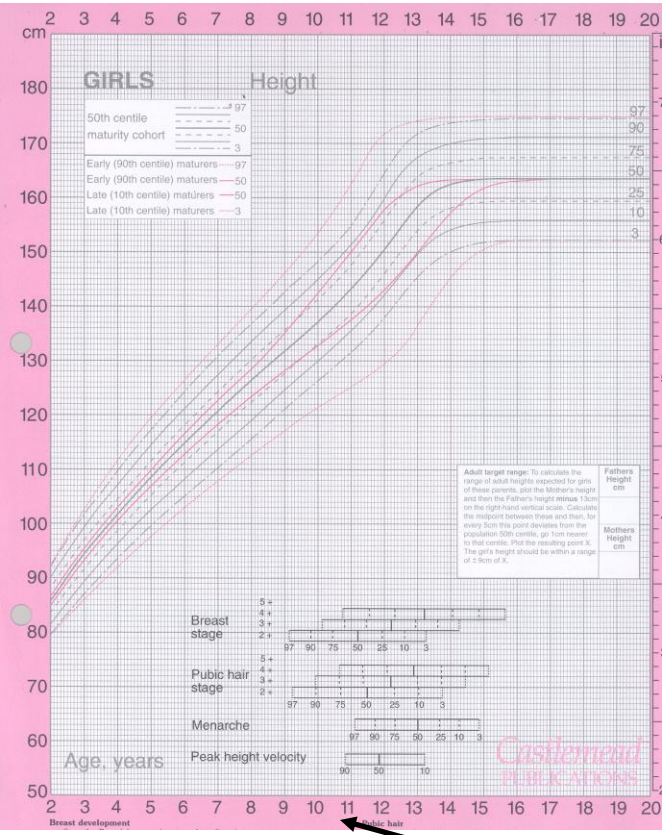
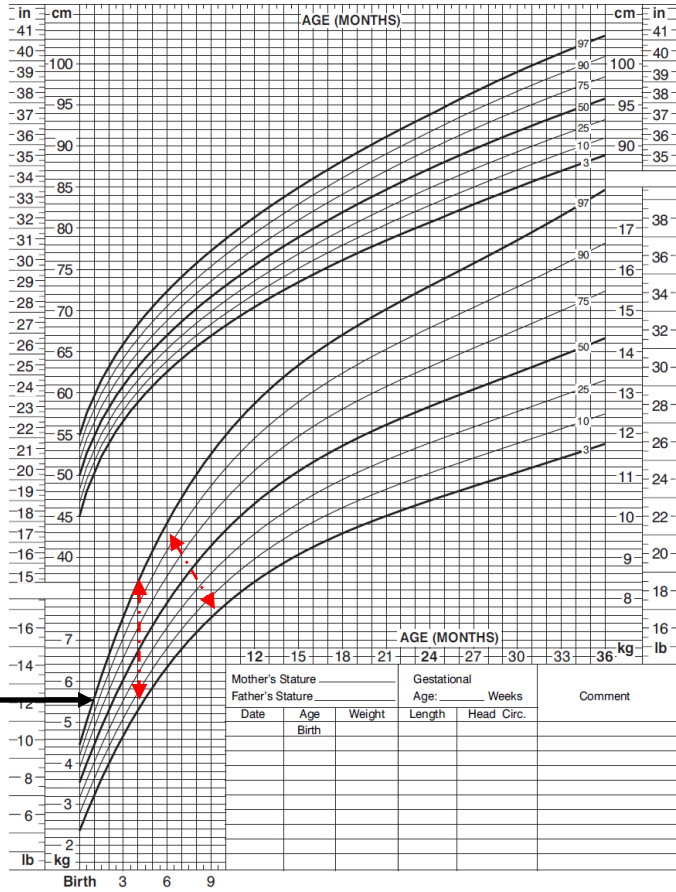
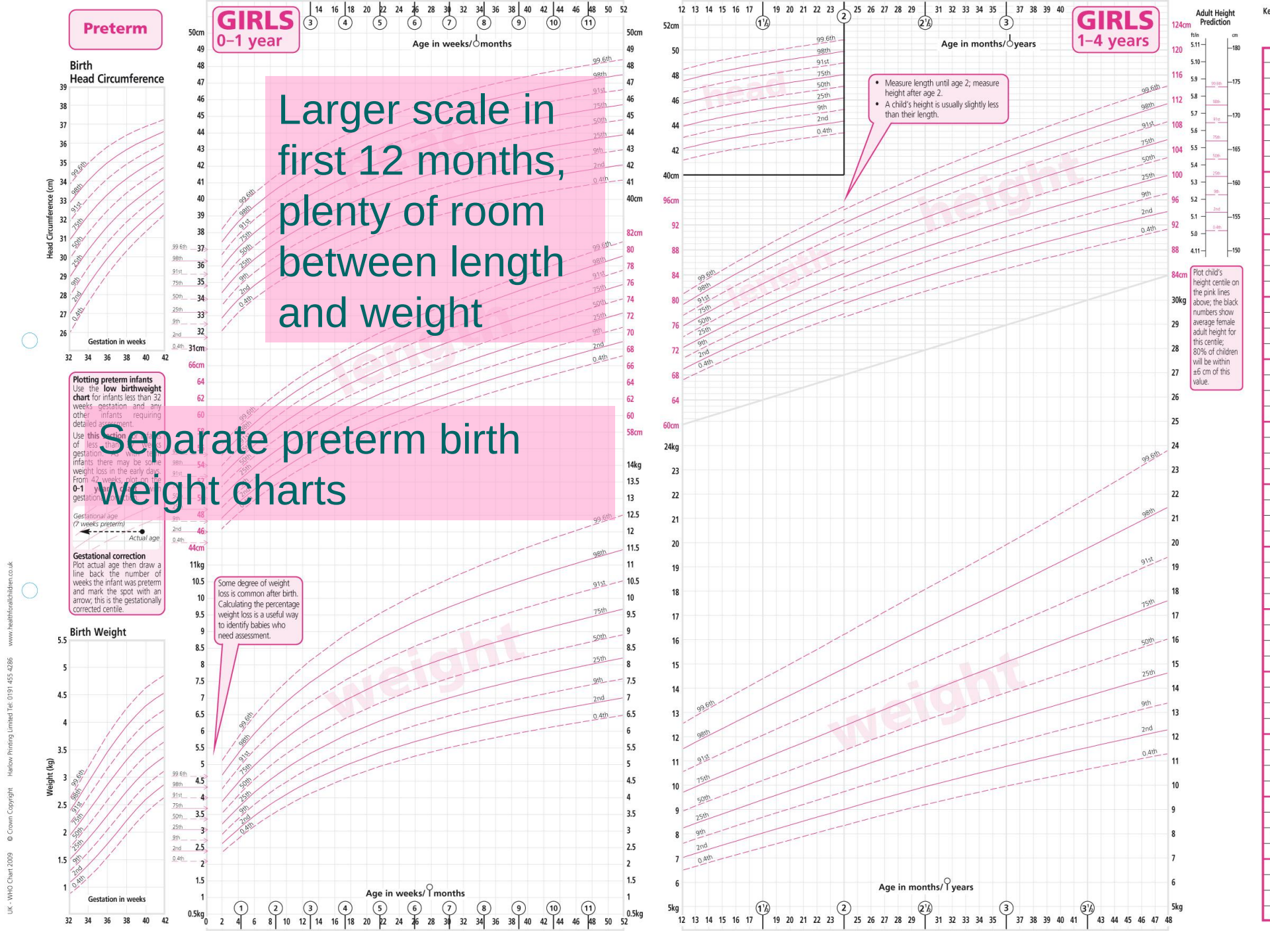
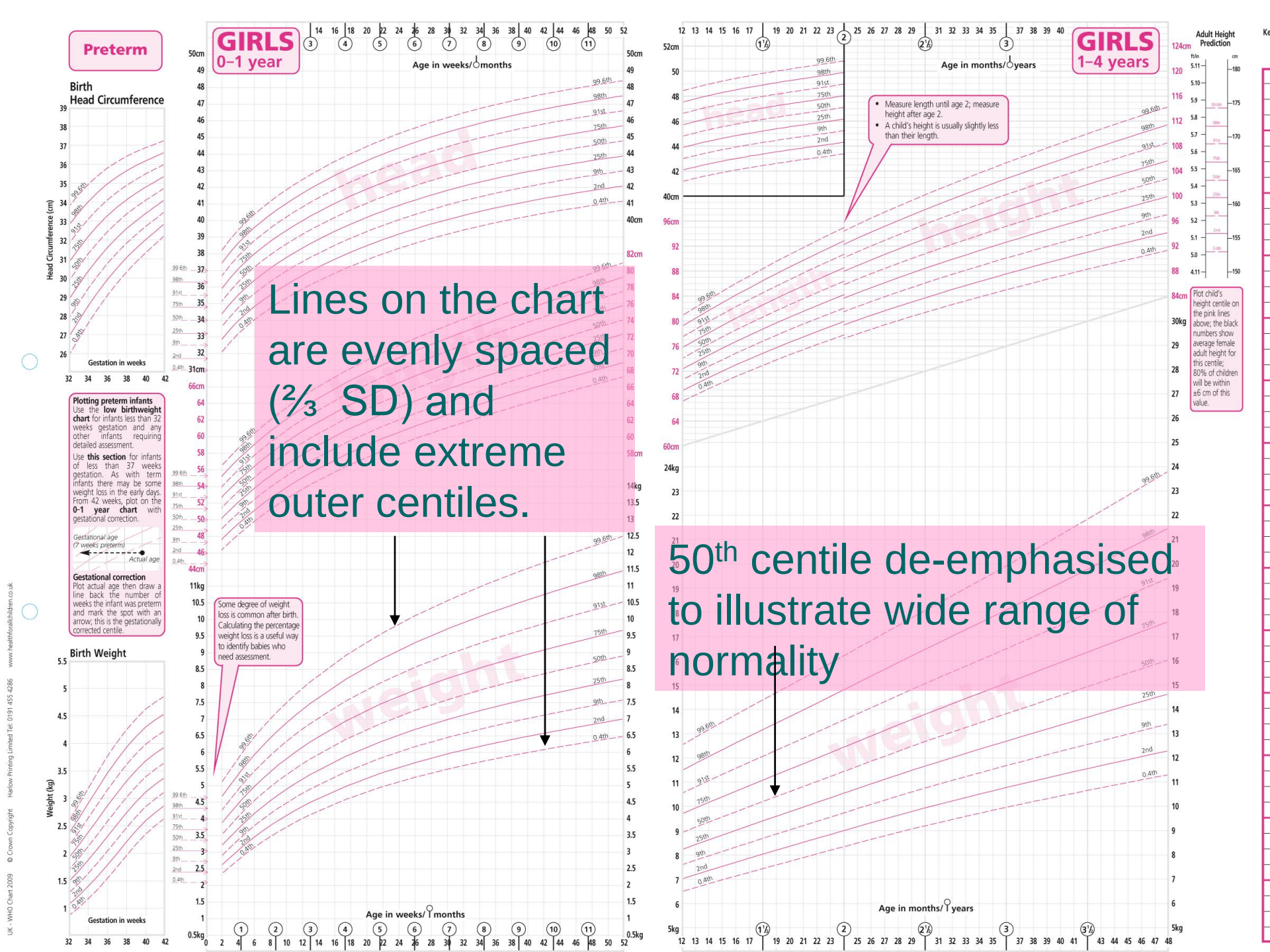


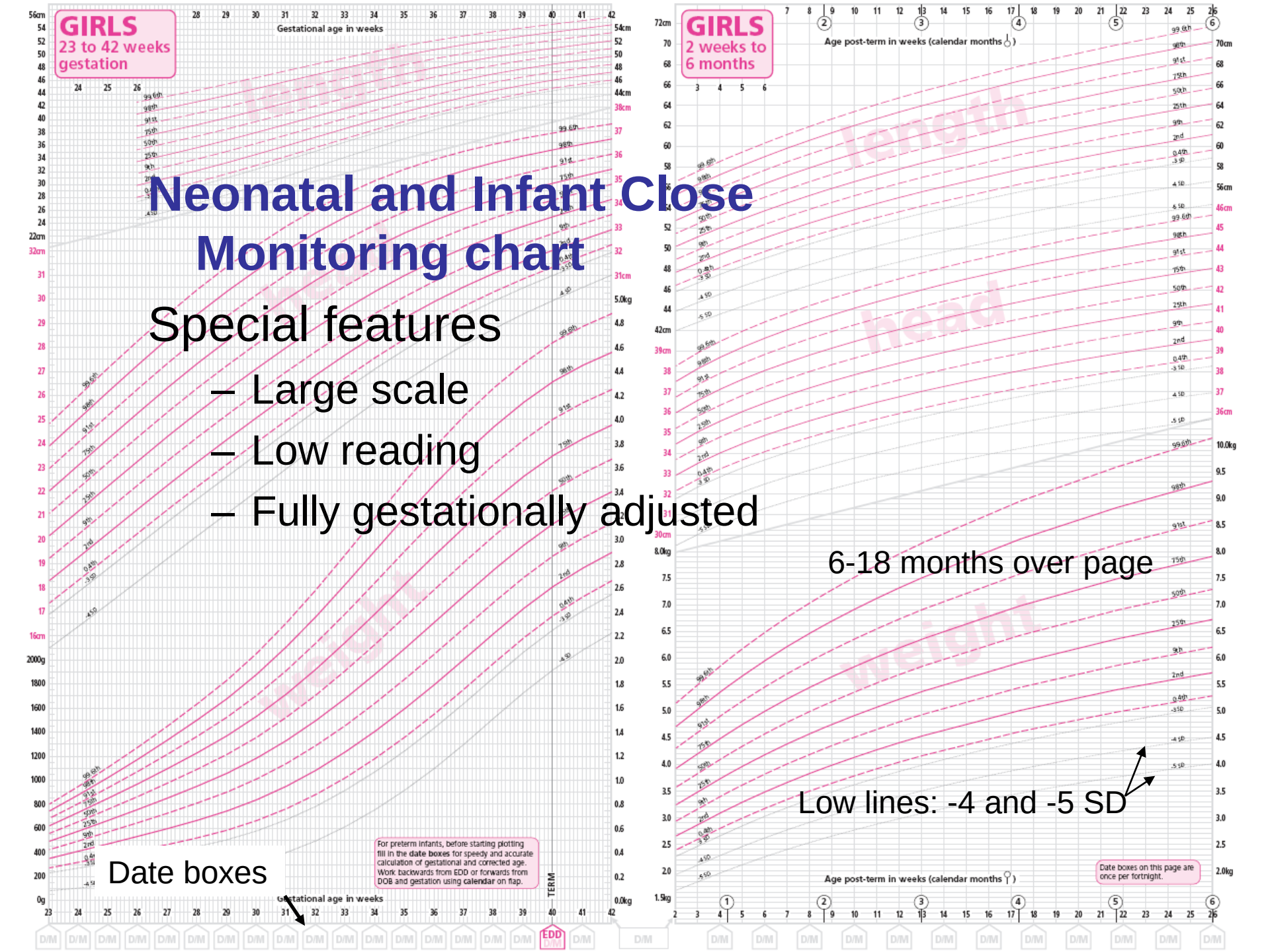
Curve too steep and narrow to read effectively



Very large scale, only useable for long time periods






GIRLS
23 to 42 weeks gestation
Gestational age in weeks
GIRLS
2 weeks to 6 months
Age post-term in weeks (calendar months)
Neonatal and Infant Close Monitoring chart
Special features
– Large scale
– Low reading
– Fully gestationally adjusted
6-18 months over page
Low lines: -4 and -5 SD
Date boxes
For preterm infants, before starting plotting fill in the date boxes for speedy and accurate calculation of gestational and corrected age. Work backwards from EDD or forwards from DOB and gestation using calendar on flap.
Date boxes on this page are once per fortnight.
TERM
EDD

Instructions

- Should describe carefully worded rules for use which are
  - Well evidenced (research)
  - Agreed (consultation)
  - Explicit (evaluation)
  - Consistent with national and professional guidelines

GIRLS UK-WHO
Growth Chart 0–4 years

Department of Health | Royal College of Paediatrics and Child Health | World Health Organization

Please place sticker (if available) otherwise write in space provided.

Name: _____

NHS/CHI No: | | | | | | | | | | |

Hospital No: | | | | | | | | | | |

Date of Birth: | | / | | / | | | | |

Who should use this chart?

Anyone who measures a child, plots or interprets charts should be suitably trained, or be supervised by someone qualified to do so. For further information and training materials see www.growthcharts.rcpch.ac.uk

The growth chart for all children

The UK-WHO growth chart combines World Health Organization (WHO) standards with UK preterm and birth data. The chart from 2 weeks to 4 years of age is based on the WHO growth standard, derived from measurements of healthy, non-deprived, breastfed children of mothers who did not smoke.[1] The chart for birth measurements (32-42 weeks gestation) is based on British children measured around 1990.[2] The charts depict a healthy pattern of growth that is desirable for all children, whether breast fed or formula fed, and of whatever ethnic origin.[3]

Weighing and measuring

Weight: use only class III clinical electronic scales in metric setting. For children up to 2 years, remove all clothes and nappy; children older than 2 years should wear minimal clothing only. Always remove shoes.

Length: (before 2 years of age): proper equipment is essential (length board or mat). Measurers should be trained. The child's shoes and nappy should be removed.

Height: (from 2 years): use a rigid rule with T piece, or stadiometer; the child's shoes should be removed.

Head circumference: use a narrow plastic or paper tape to measure where the head circumference is greatest. Any hat or bonnet should be removed.

When to weigh

Babies should be weighed in the first week as part of the assessment of feeding and thereafter as needed. Recovery of birthweight indicates that feeding is effective and that the child is well. Once feeding is established, babies should usually be weighed at around 8, 12 and 16 weeks and 1 year at the time of routine immunisations. If there is concern, weigh more often; however, weights measured too close together are often misleading, so babies should be weighed no more than once a month up to 6 months of age, once every 2 months from 6 to 12 months of age, and once every 3 months over the age of 1 year. However, most children do not need to be weighed this often.

When to measure length or height

Length or height should be measured whenever there are any worries about a child's weight gain, growth or general health.

Plotting measurements

For babies born at term (37 weeks or later), plot each measurement on a relevant chart by drawing a horizontal line where a vertical line through the child's age crosses a horizontal line through the measured value. The lettering on the charts ('weight', 'length' etc.) sits on the 50th centile, providing orientation for ease of plotting.

Plot birth weight (and, if measured, length and head circumference) at age 0 on the 0–1 year chart. The coloured arrows at age 0 represent UK birth weight data and show the child's birth centile.

Weight gain in the early days varies a lot from baby to baby, so there are no lines on the chart between 0 and 2 weeks. However, by 2 weeks of age most babies will be on a centile close to their birth centile.

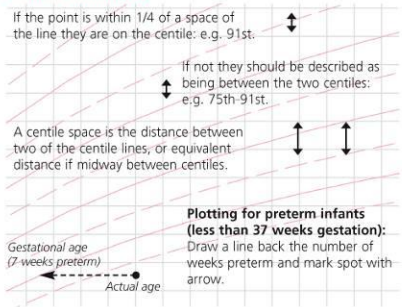
For **preterm infants** a separate low birth weight chart is available for infants of less than 32 weeks gestation and any other infant requiring detailed assessment. For healthy infants born from 32 weeks and before 37 weeks, plot all measurements in the preterm section (to the left of the main 0–1 year chart) until 42 weeks gestation, then plot on the 0–1 year chart using gestational correction, as shown below.

The preterm section can also be used to assess the relative size of infants at the margin of 'term' (e.g. 37 weeks gestation), but these measurements should also be plotted at age 0 on the 0–1 year chart.

Gestational correction

Plot measurements at the child's actual age and then draw a line back the number of weeks the infant was preterm. Mark the spot with an arrow (see diagram): this is the child's gestationally corrected centile. Gestational correction should continue until at least 1 year of age.

Centile terminology



Interpreting the chart

Assessing weight loss after birth

Most babies lose some weight after birth but 80% will have regained this by 2 weeks of age. Fewer than 5% of babies lose more than 10% of their weight at any stage; only 1 in 50 are 10% or more lighter than birth weight at 2 weeks.

Percentage weight loss can be calculated as follows:

Weight loss = current weight – birth weight

$$\text{Percentage weight loss} = \frac{\text{Weight loss}}{\text{Birth weight}} \times 100\%$$

For example, a child born at 3.500kg who drops to 3.150kg at 5 days has lost 350g or 10%; in a baby born at 3.000kg, a 300g loss is 10%.

Careful clinical assessment and evaluation of feeding technique is indicated when weight loss exceeds 10% or regain of birth weight is slow.

What do the centiles mean?

These charts indicate a child's size compared with children of the same age and maturity who have shown optimum growth. The chart also shows how quickly a child is growing. The centile lines on the chart show the expected range of weights and heights (or lengths); each describes the number of children expected to be below that line (e.g. 50% below 50th, 91% below the 91st). Children come in all shapes and sizes, but 99 out of 100 children who are growing optimally will be between the two outer lines (0.4th and 99.6th centiles); half will lie between the 25th and 75th centile lines.

Being very small or very big can sometimes be associated with underlying illness. There is no single threshold below which a child's weight or height is definitely abnormal, but only 4 per 1000 children who are growing optimally are below the **0.4th centile**, so these children should be assessed at some point to exclude any problems. Those above the **99.6th centile** for height are almost always healthy. Also calculate BMI if weight and height centiles appear very different.

What is a normal rate of weight gain and growth?

Babies do not all grow at the same rate, so a baby's weight often does not follow a particular centile line, especially in the first year. Weight is most likely to track within one centile space (the gap between two centile lines, see diagram). In infancy, acute illness can lead to sudden weight loss and a weight centile fall but on recovery the child's weight usually returns to its normal centile within 2–3 weeks. However, a sustained drop through two or more weight centile spaces is unusual (fewer than 2% of infants) and should be carefully assessed by the primary care team, including measuring length/height.

Because it is difficult to measure length and height accurately in pre-school children, successive measurements commonly show wide variation. If there are worries about growth, it is useful to measure on a few occasions over time; most healthy children will show a stable *average* position over time.

Head circumference centiles usually track within a range of one centile space. After the first few weeks a drop or rise through two or more centile spaces is unusual (fewer than 1% of infants) and should be carefully assessed.

Why do the length/height centiles change at 2 years?

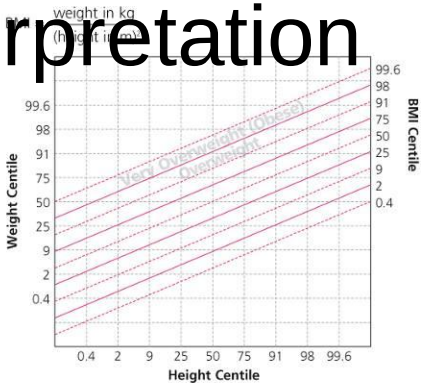
The growth standards show length data up to 2 years of age, and height from age 2 onwards. When a child is measured standing up, the spine is squashed a little, so their height is slightly less than their length; the centile lines shift down slightly at age 2 to allow for this. It is important that this difference does not worry parents; what matters is whether the child continues to follow the same centile after the transition.

Predicting adult height

Parents like to know how tall their child will be as an adult. The child's most recent height centile (aged 2–4 years) gives a good idea of this for healthy children. Plot this centile on the adult height predictor to the right of the height chart to find the average adult height for children on this centile. Four out of five children will have adult heights that are within 6cm above or below this value.

Weight–height to BMI conversion chart

BMI indicates how heavy a child is relative to his or her height and is the simplest measure of thinness and fatness from the age of 2, when height can be measured fairly accurately. This chart[4] provides an approximate BMI centile, accurate to a quarter of a centile space.



Date:				
Age:				
BMI Centile:				

Instructions for use

1. Read off the weight and height centiles from the growth chart.
2. Plot the weight centile (left axis) against the height centile (bottom axis) on the chart above.
3. If between centiles, read across in this position.
4. Read off the corresponding BMI centile from the slanting lines.
5. Record the centile with the date and child's age in the data box.

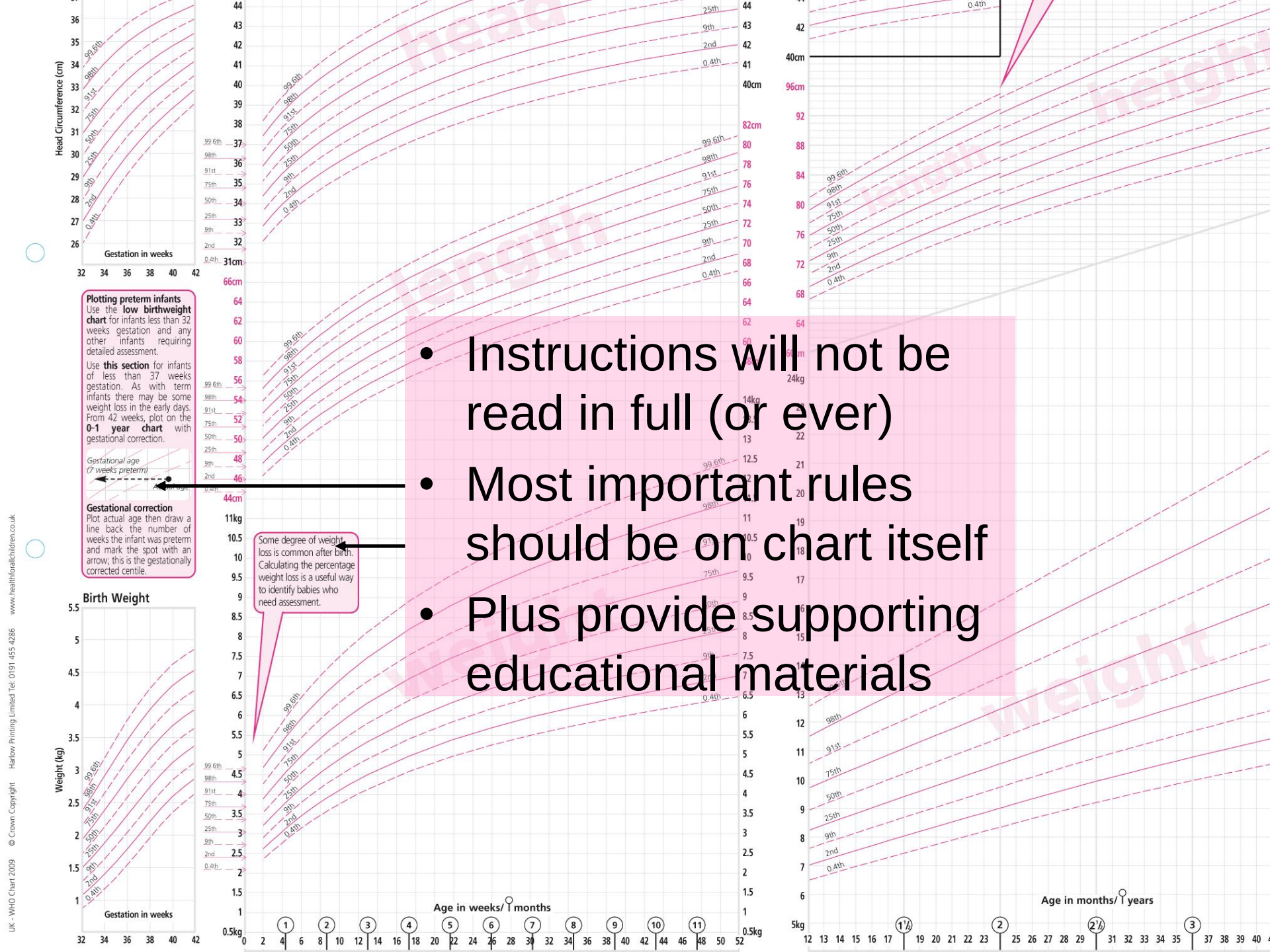
Interpretation

In a child over 2 years of age, the BMI centile is a better indicator of overweight or underweight than the weight centile; a child whose weight is average for their height will have a BMI between the 25th and 75th centiles, whatever their height centile. BMI above the 91st centile suggests that the child is overweight; a child above the 98th centile is very overweight (clinically obese). BMI below the 2nd centile is unusual and may reflect undernutrition.

References

1. www.who.int/childgrowth/en
2. 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. Stat Med 1998;17:407-29.
3. www.sacn.gov.uk/reports_position_statements/index.html
4. Cole TJ. A chart to link child centiles of body mass index, weight and height. Eur J Clin Nutr 2002;56:1194-9.

Measuring, plotting, terminology, interpretation



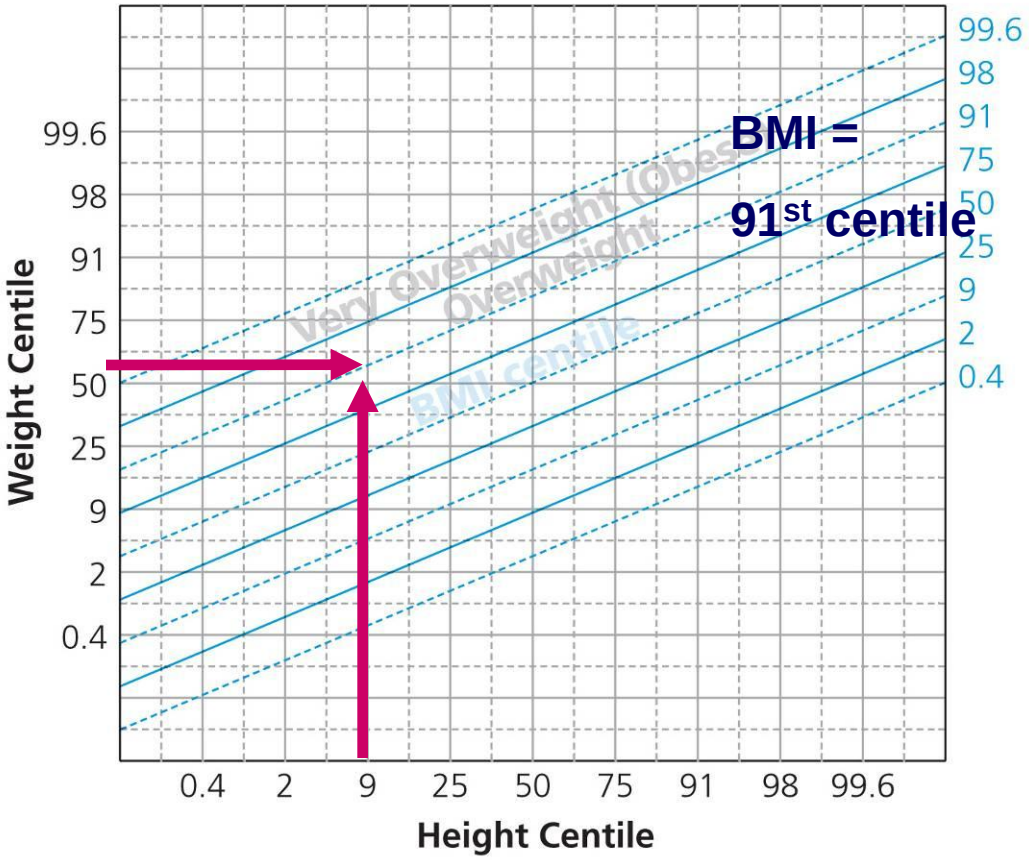
- Instructions will not be read in full (or ever)
- Most important rules should be on chart itself
- Plus provide supporting educational materials

Ease and simplicity of use

- Some things are just too hard for many staff, particularly when under pressure

Body Mass Index (BMI) centile lookup

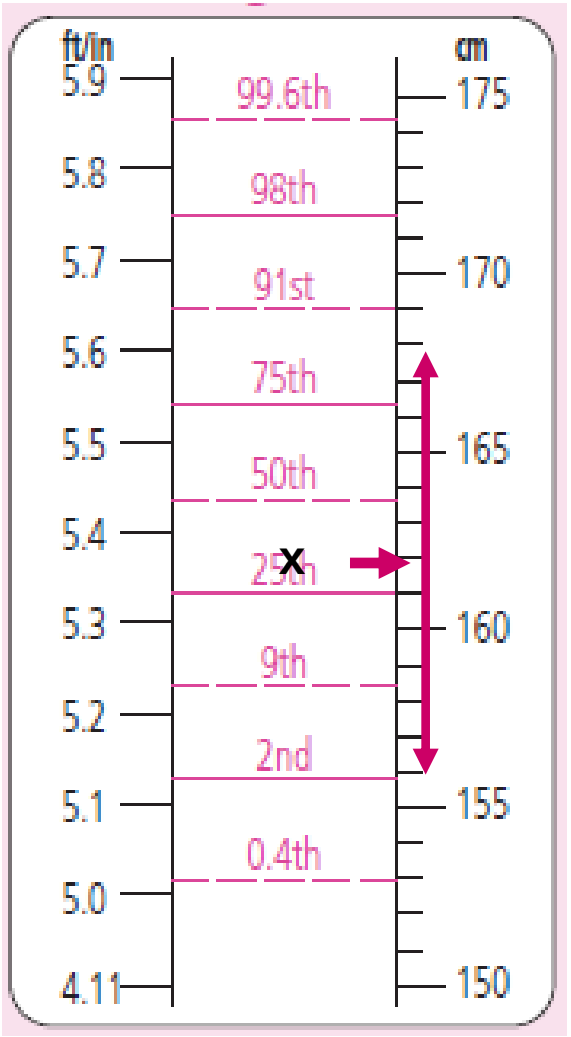
- Read weight and height centiles from the growth chart.
- Plot weight centile against the height centile
- Read off the corresponding BMI centile from the slanting lines
- Accurate to within ¼ centile space



Predicted Adult Height

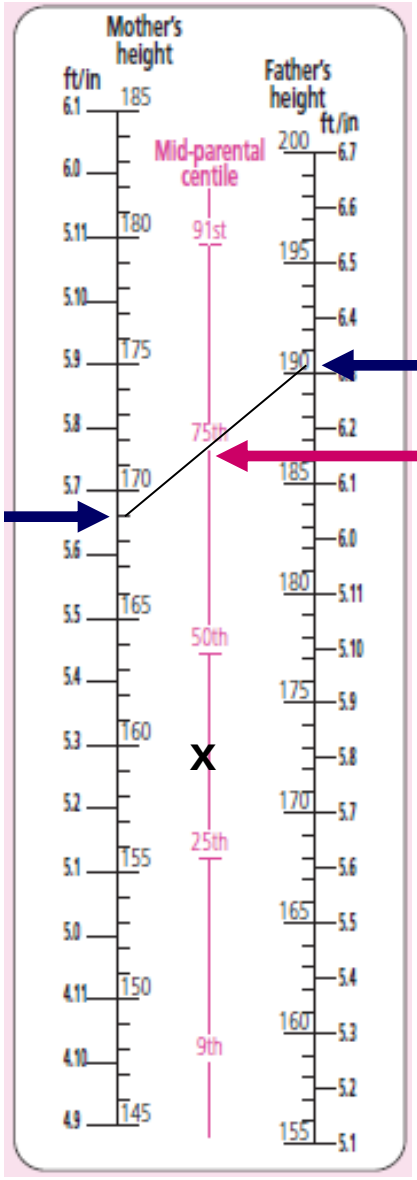
Uses child's current centile to predict adult height

80% of children will be within ±6 cm of predicted value



Mid-parental Centile comparator

- Plot mothers and father's height on outer scale and read off MPC from middle scale
- MPC is average centile for all children of these parents: doesn't predict actual adult height
- Children of very tall or short parents have mid parental centile nearer to average
- Used to compare with child's actual centile



Summary

- Charts are a clinical assessment tool that need the same attention to design as any item of equipment
- Layout should fully (and only) reflect meaning and proposed use
- Drafting the instructions should drive the design process
- Formal testing and consultation are essential

Acknowledgments

Chart Working Group
Charlotte Wright, Tim Cole, David Elliman, Helen Bedford, Tony Williams, Gary Butler, Eilee Birks, John Short
Pre school: Rob Moy, Magda Sachs
School Age: Penny Gibson, Mary Rudolf, Hilary Hoey, Lynn Ahmed

Design: Diane Hall, Christine Charlton

Preterm and neonatal: Caroline King, Helen Mactier, Judith Simpson, Peter Macdonald

RCPCH: Linda Haines, Terence Stephenson, Neena Modi, Stephen Van Vloten, Jyotsna Vorha

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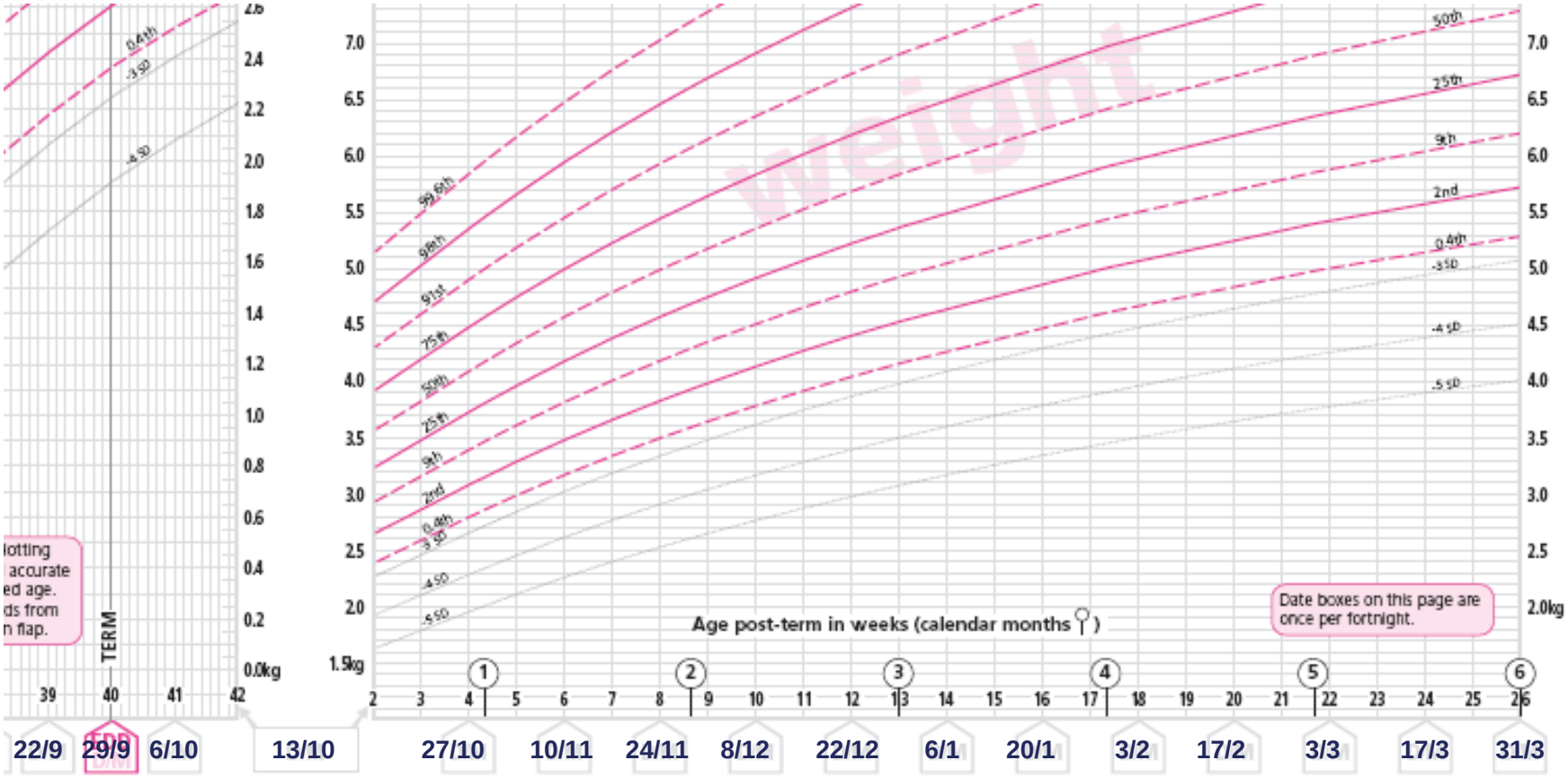
All charts and supporting materials can be freely downloaded from:

growthcharts.RCPCH.ac.uk

Paper charts can be purchased from Harlow Printing
Or printed locally as long as printing specification are met

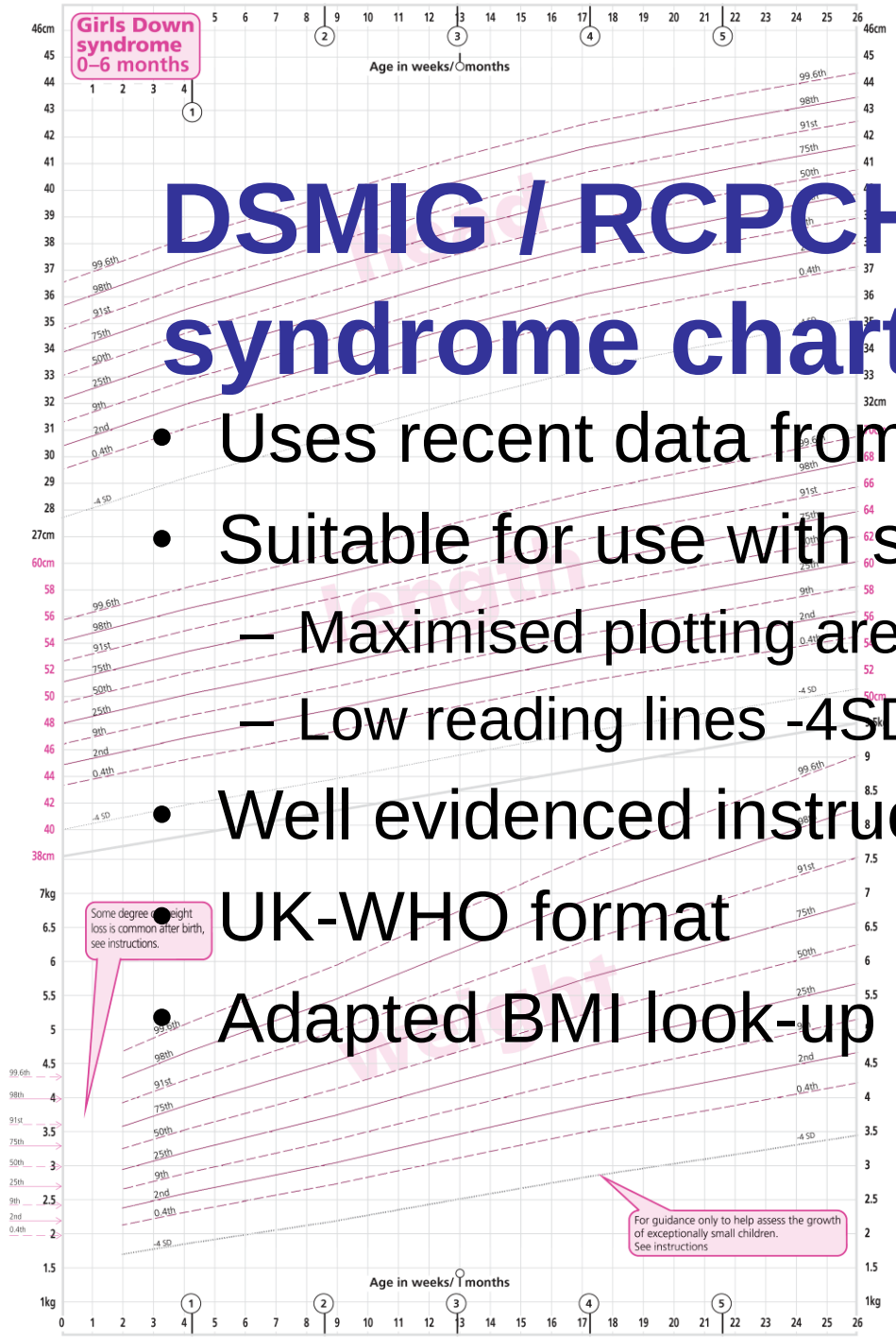
Date boxes: NICM Preterm chart

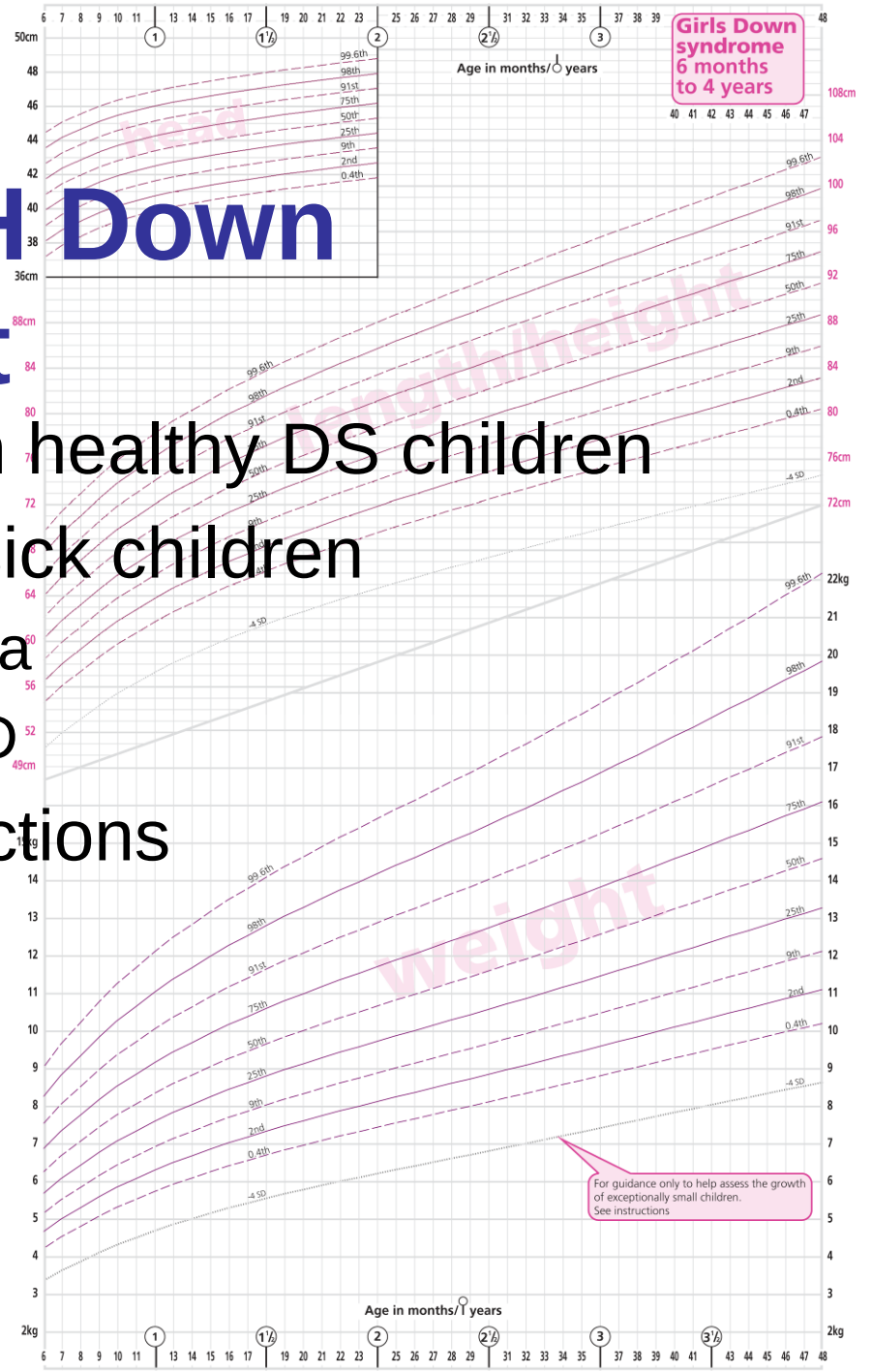
Allow direct plotting of gestationally corrected age by date, without calculation



Design process for preschool charts

- Expert team convened
- Designers appointed
- Initial parental consultation
- Design questions tested with initial professional focus groups
- Resulting prototypes and instructions tested with 7 further focus groups
- Stakeholder consultation

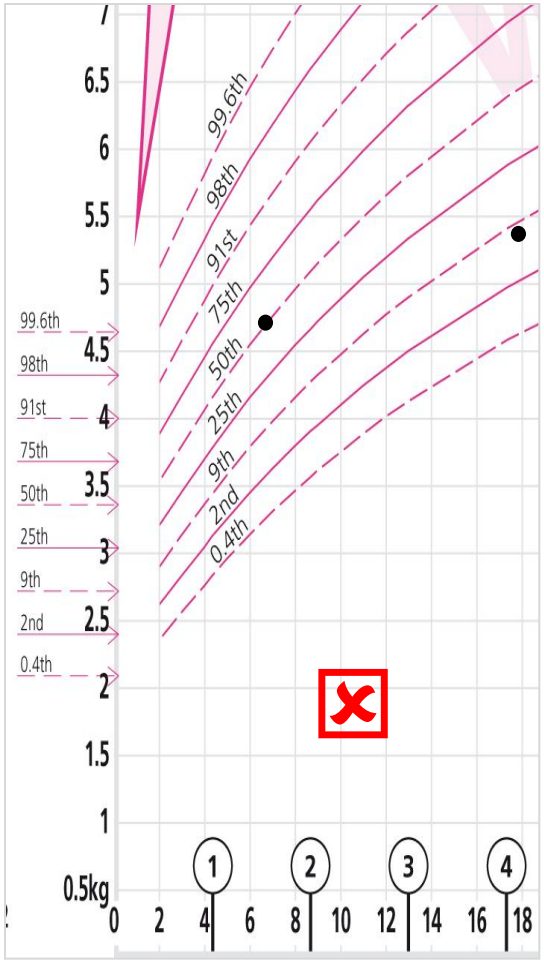




DSMIG / RCPCH Down syndrome chart

- Uses recent data from healthy DS children
- Suitable for use with sick children
  - Maximised plotting area
  - Low reading lines -4SD
- Well evidenced instructions
- UK-WHO format
- Adapted BMI look-up

Failure to allow for gestation



- Need to be clear which plots are adjusted for gestation
- Other users may not adjust
- Could place child at risk