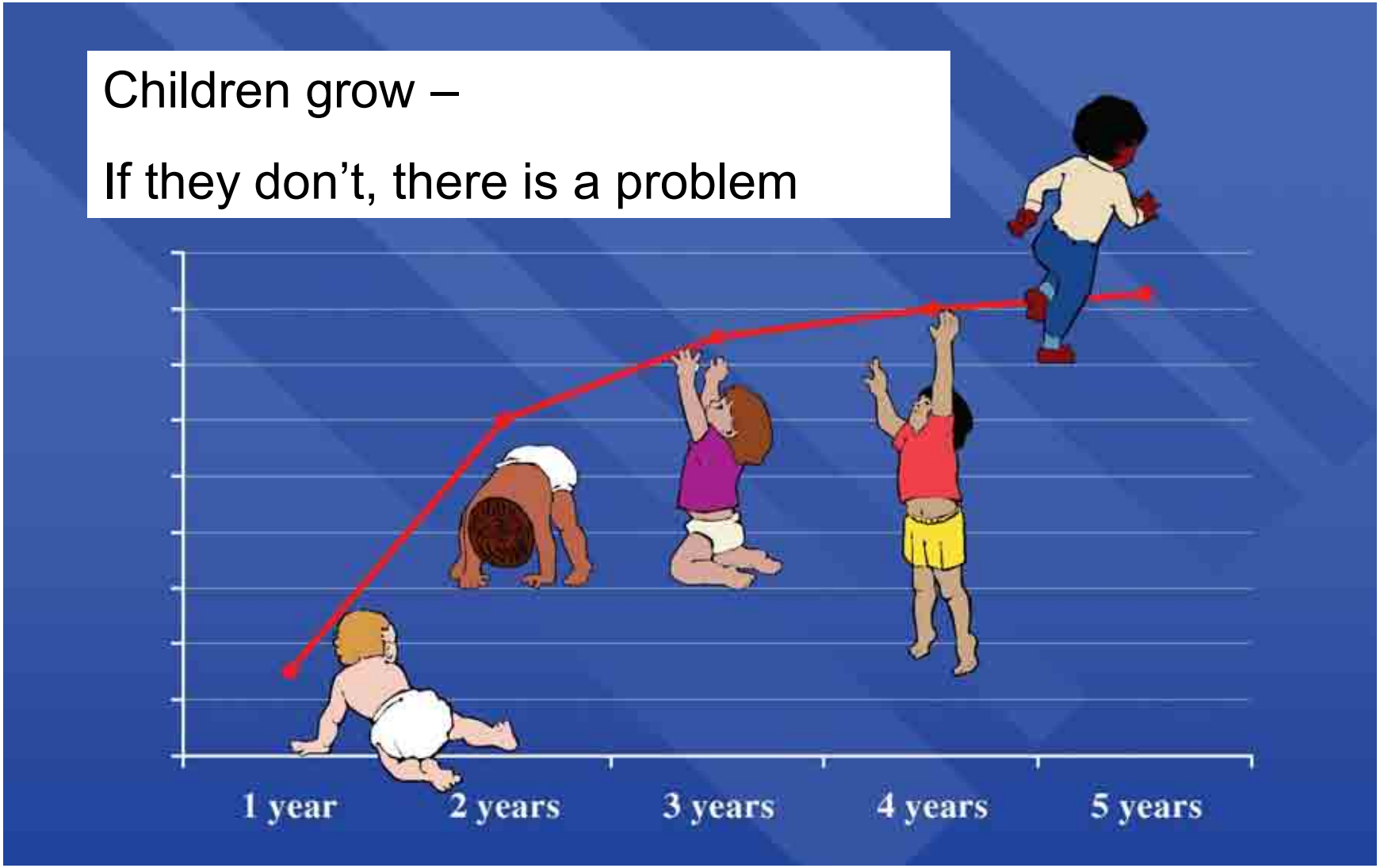
Growth charts and Z-scores

Prof DF Wittenberg

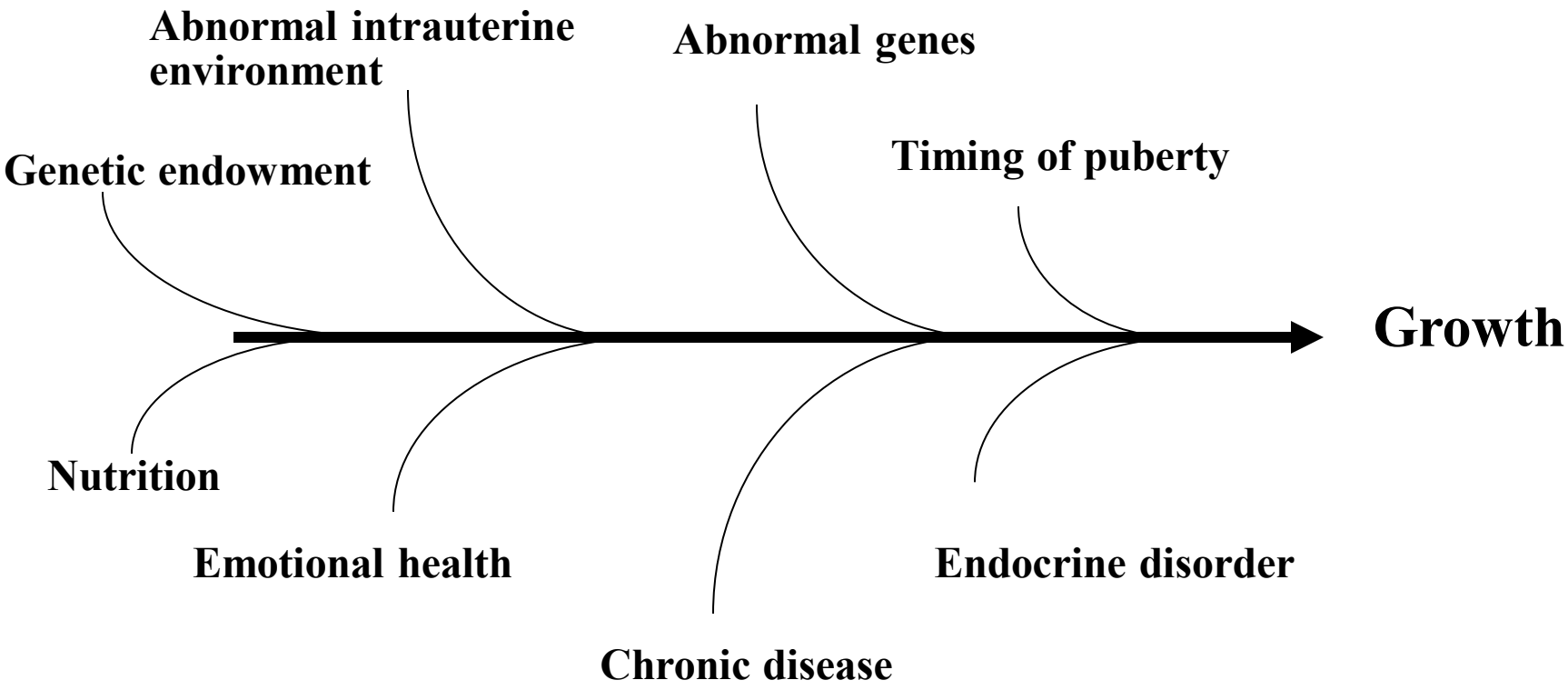
Children grow –

If they don't, there is a problem



Standardized tables or charts are used to assess weight, length or height, skull circumference, and growth velocity

Factors affecting the individual's growth



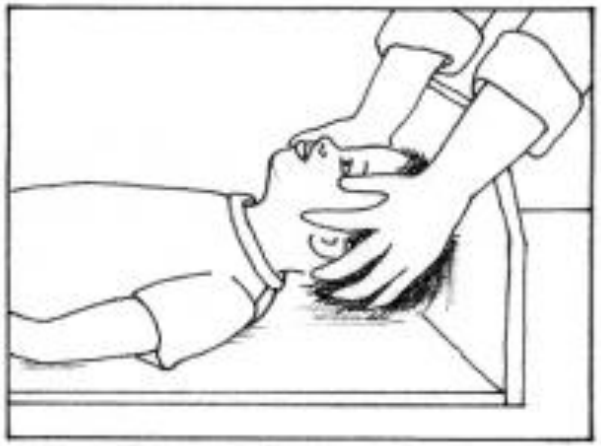
Main influence on growth

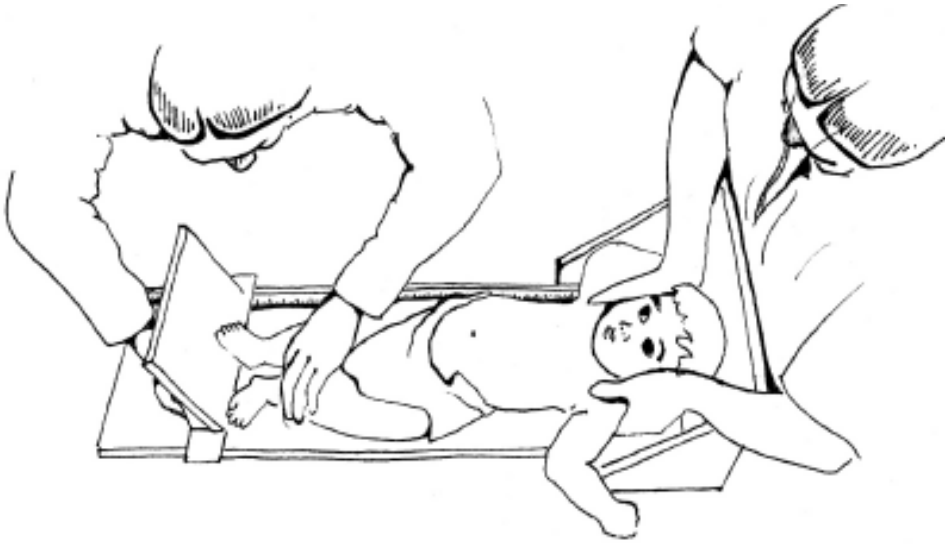
- Infancy : (up to 2 years)
  - Food/ nutrition
  - Chronic disease
- Childhood
  - Genes
  - Growth Hormones
  - Chronic disease
- Puberty
  - Sex hormones

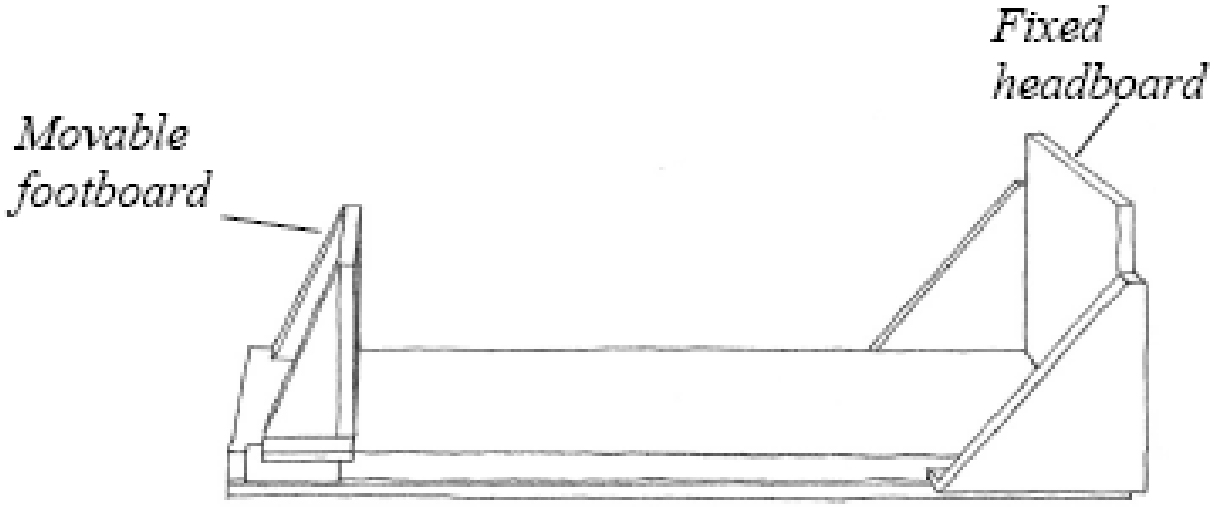
Is this boy really 6 years old?

Measurement is the only way to recognize whether growth is normal or not

Length vs height







Measurement of stature

Feet flat together against the wall

Buttocks, Back against the wall

Stand straight!

Horizontal mark opposite top of head

Measure against the wall

Measurement of growth

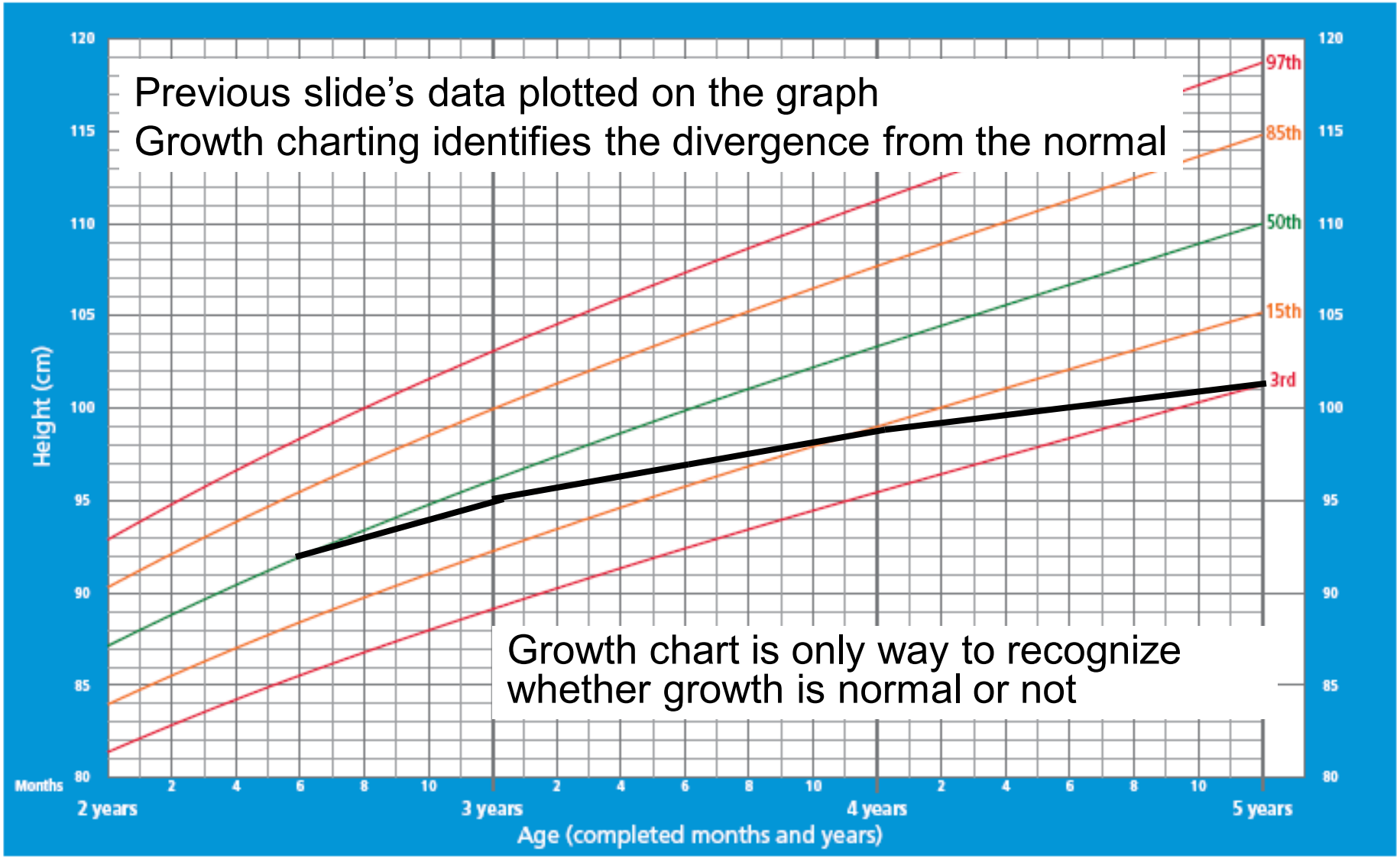
- Length or height measurement
- Example of a little boy's data:

eg	Age	Ht
	2.5 yrs	92 cm
	3.0 yrs	95 cm
	3.5 yrs	97 cm
	4.0 yrs	99 cm
	5.0 yrs	101 cm

Height-for-age BOYS

2 to 5 years (percentiles)

World Health Organization



WHO Child Growth Standards

The most important feature of growth charts

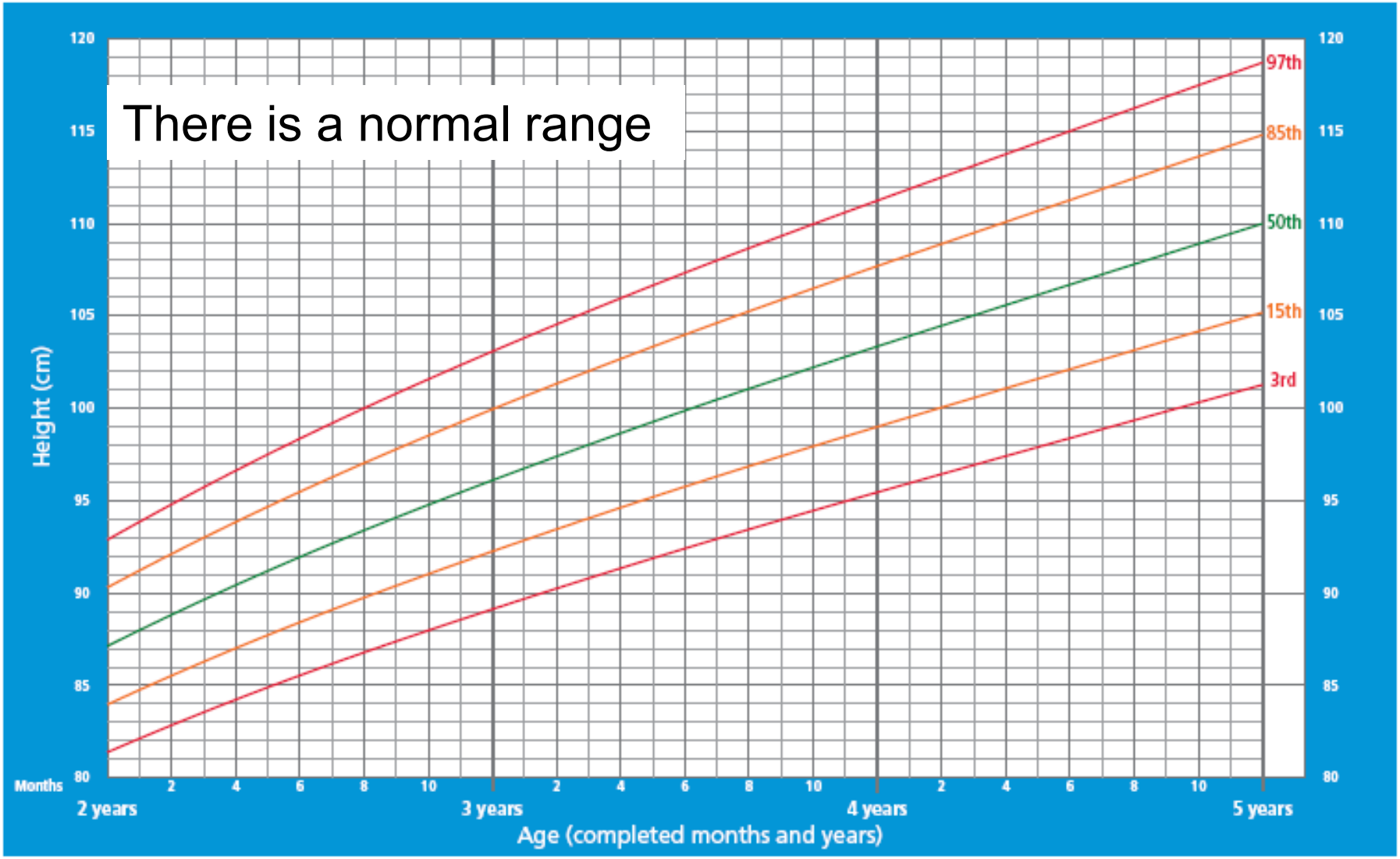
- A measure to compare and monitor the physical status of an individual child with the childhood population on an ongoing basis.

- **Different types of growth charts**
  - Road-to-Health Chart :
    - mainly a weight for age chart
  - Longitudinal growth charts
    - Percentile graphs
    - Z score graphs
  - BMI charts
  - Weight for length/height charts
  - Velocity charts
- Prenatal or combined pre- and postnatal growth charts
- Special populations : Down syndrome , Turner syndrome

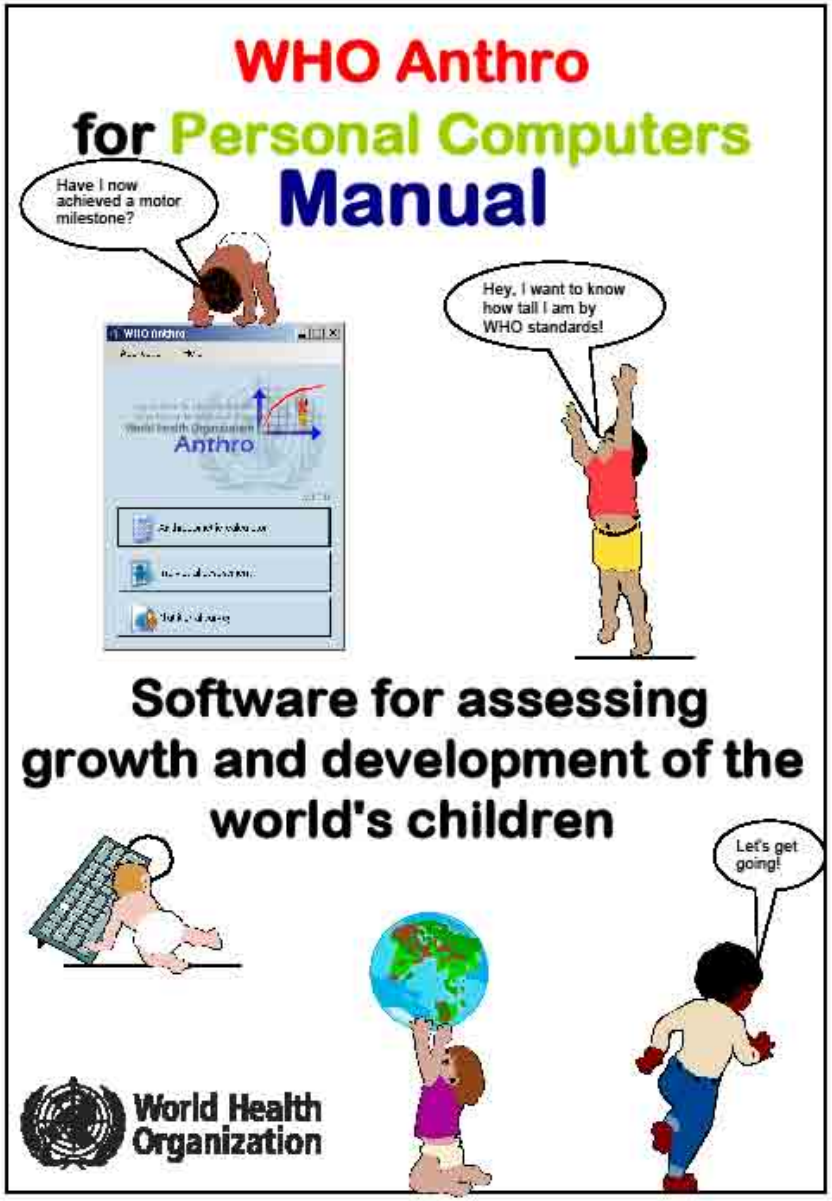
Height-for-age BOYS

2 to 5 years (percentiles)

World Health Organization



WHO Child Growth Standards



www.who.int/growth

Percentile or Z-score graphs

- **Of 100 healthy children at a given age:**

  3 per cent have height measurements less than the 3rd percentile

  97 of 100 children have measurements below the 97th percentile

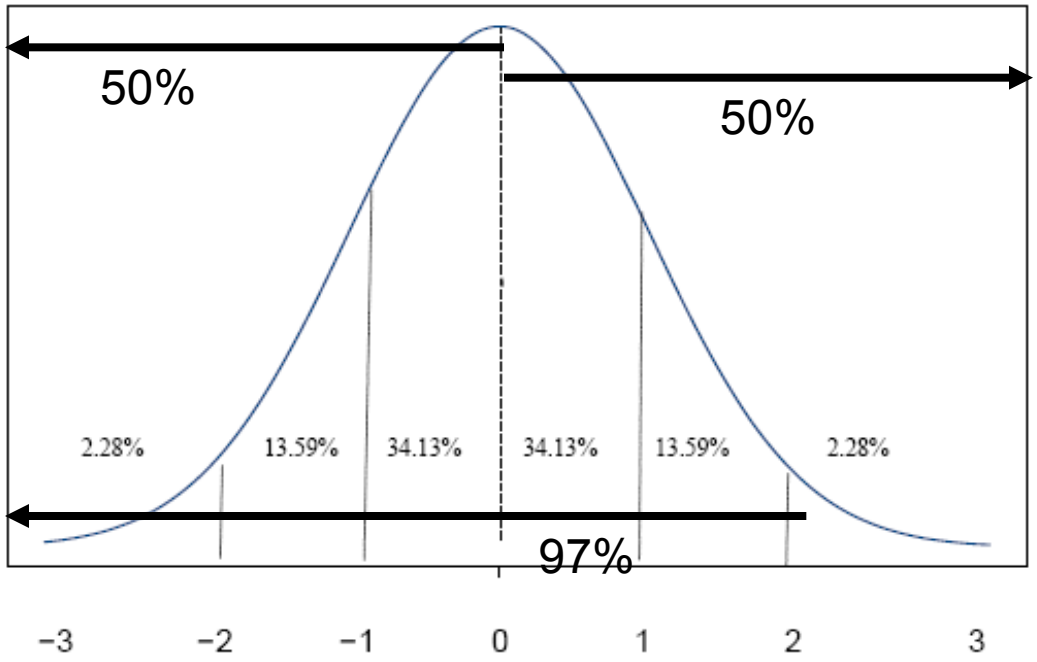
  50 per cent above or under the 50th percentile

  50th percentile measurements correspond to the mean and median

- **Z-scores or SD scores** are used to describe mathematically how far a measurement is from the median (average).

- The mean (median) is the same in both types of graph

Range of normal



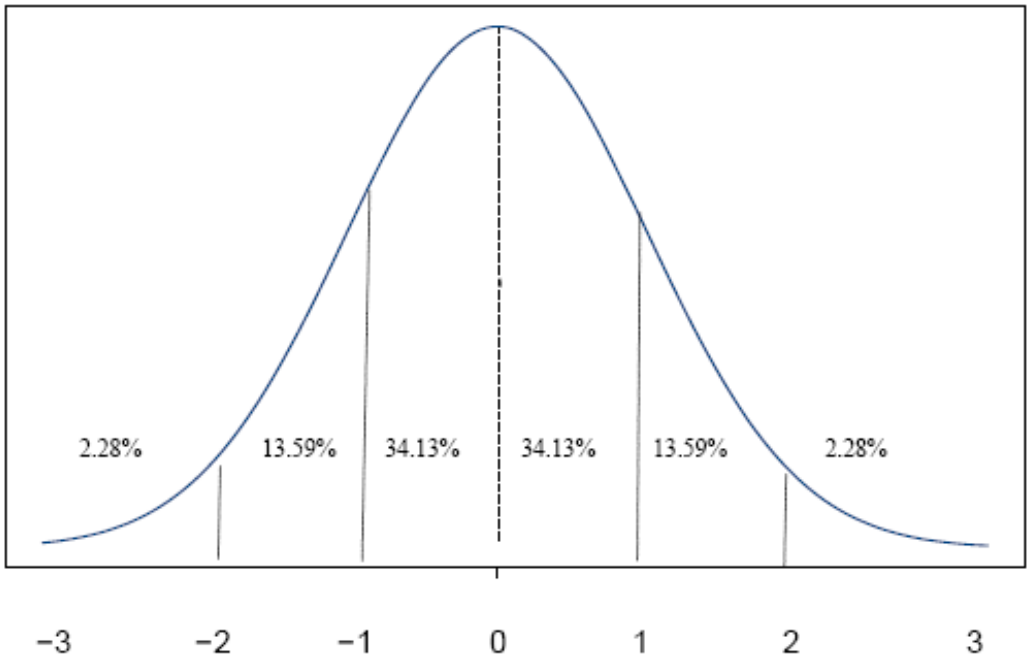
50th percentile corresponds to a Z score of 0

3 rd percentile corresponds to Z score of – 1.72

97th percentile corresponds to a Z score of + 1.72

How to calculate Z scores (Standard Deviation Score)

$$\text{z-score} = \frac{\text{(observed value)} - \text{(median reference value)}}{\text{z-score of the reference population}}$$



Example:

Actual length 96.1 cm

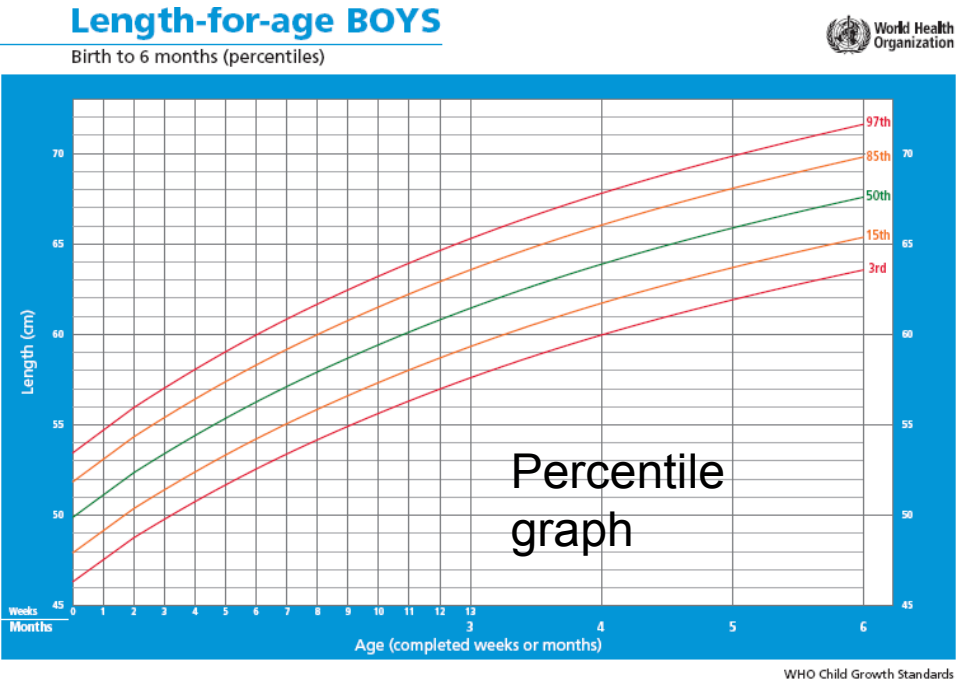
Median 90.4 cm

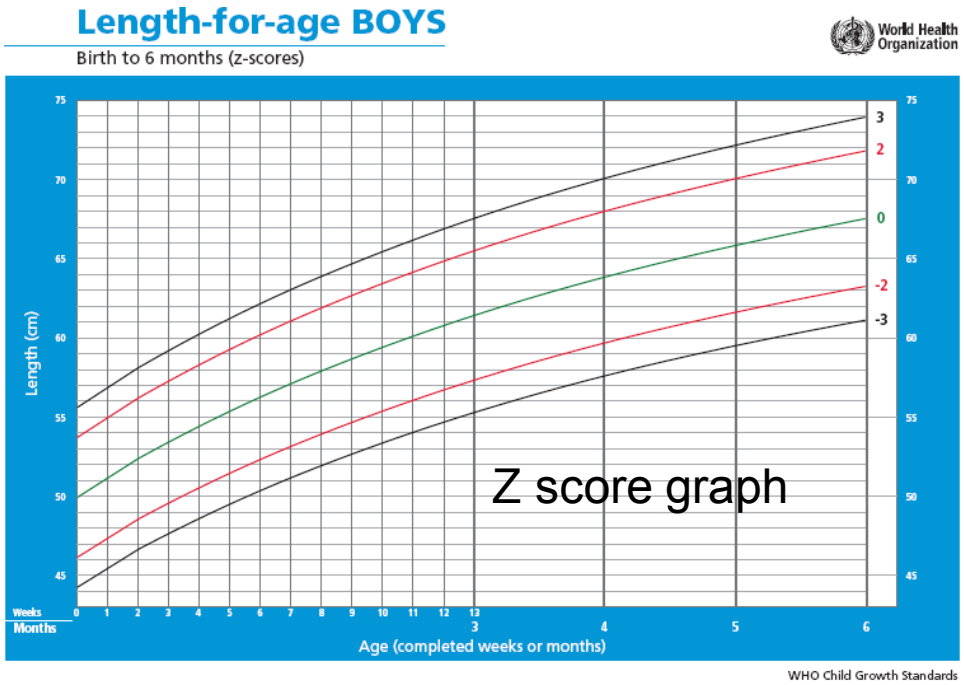
Standard deviation 3.3

Z score = 5.7/3.3

= +1.73

Comparison of growth charts





Percentile graphs have a narrower range, because the 97th centile corresponds approximately to a Z score +2

A Z-score of +3 or -3 is more likely to be definitely abnormal

NCHS or WHO charts

- Growth charts are established on large populations of normal children living under near-optimal conditions and therefore representing the range of normal growth for children at different ages.

- NCHS : USA population, cross-sectional

- New growth standards have been developed by the World Health Organization (WHO) based on the growth of normal breast fed infants in various regions of the world. **International growth reference standard**

Growth of breastfed babies
Pooled data from affluent countries

- Growth patterns of BF babies similar in different populations
- Slower weight gain from age 3-12 months
- Deviation of growth occurs when babies are already on solids, ie not deficiency
- Less effect on length than weight
- At 2 years average weight close to reference

Dewey KG, *et al.* ***Pediatrics 1995; 96 (3): 495 - 503***

Comparison of breastfed growth with CDC growth curves

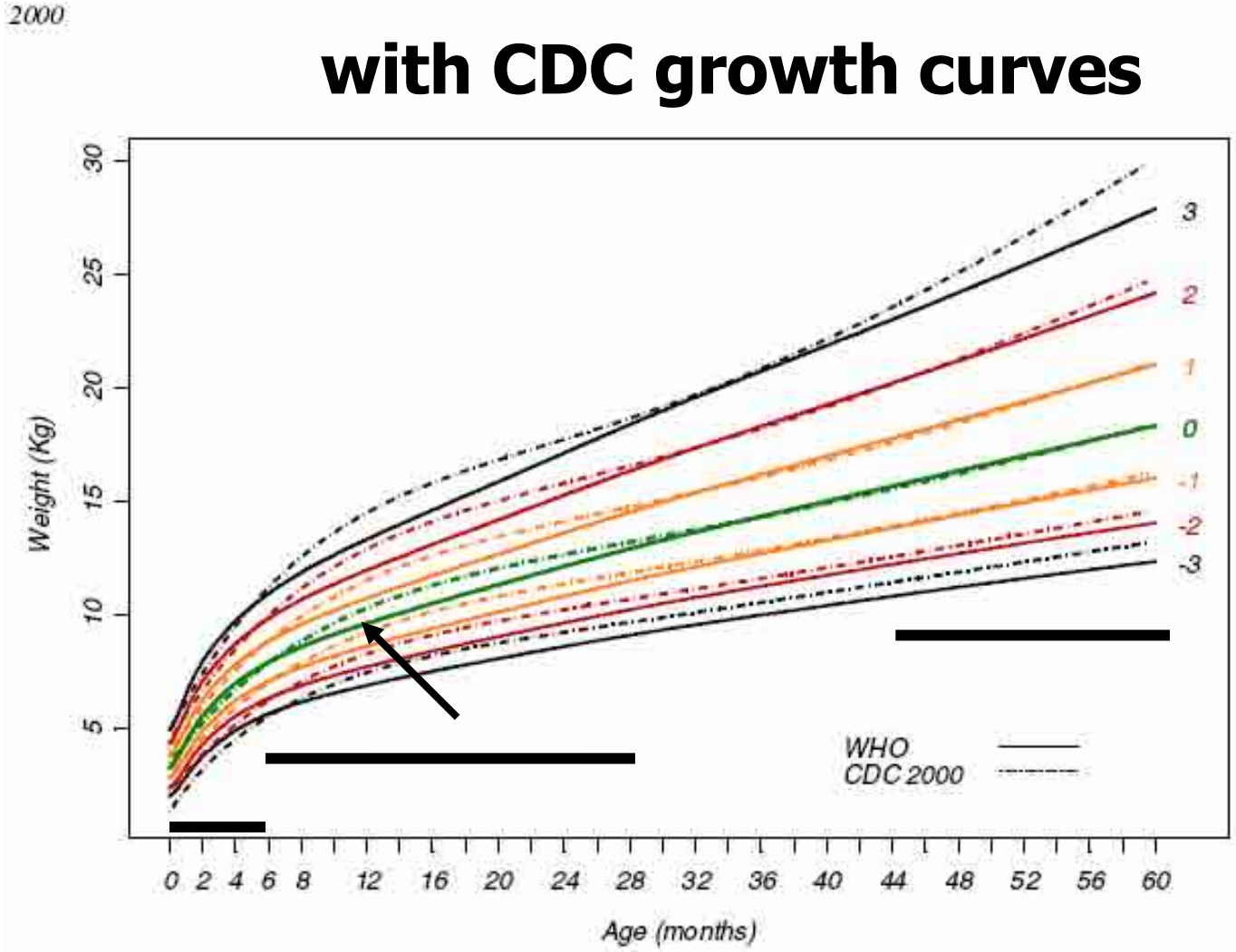


Figure 46 Comparison of WHO with CDC 2000 weight-for-age z-scores for boys

From : ***WHO 2006***

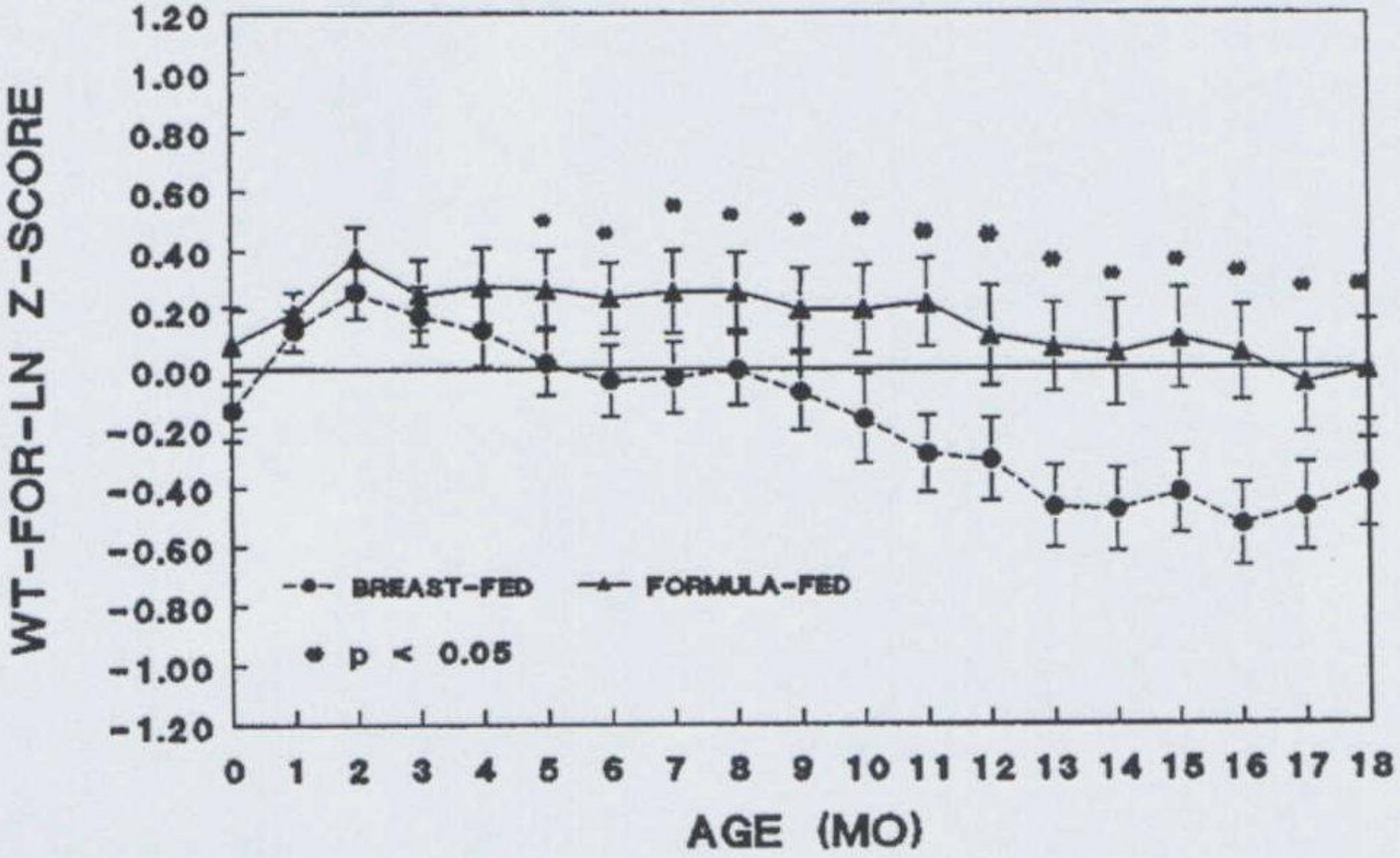


Fig 5. Weight-for-length z scores (mean ± SEM) of breast-fed and formula-fed infants from birth to 18 months.

Dewey et al ***Pediatrics 1992; 89: 1035-1041***

Final height of breastfed babies

- Slow growth in second 6 months of life despite additional solids
- Other factors than breastfeeding *per se* apparently responsible for associations
- Final height is no different from formula-fed babies

  Girls 165.3 vs 164.9 cm

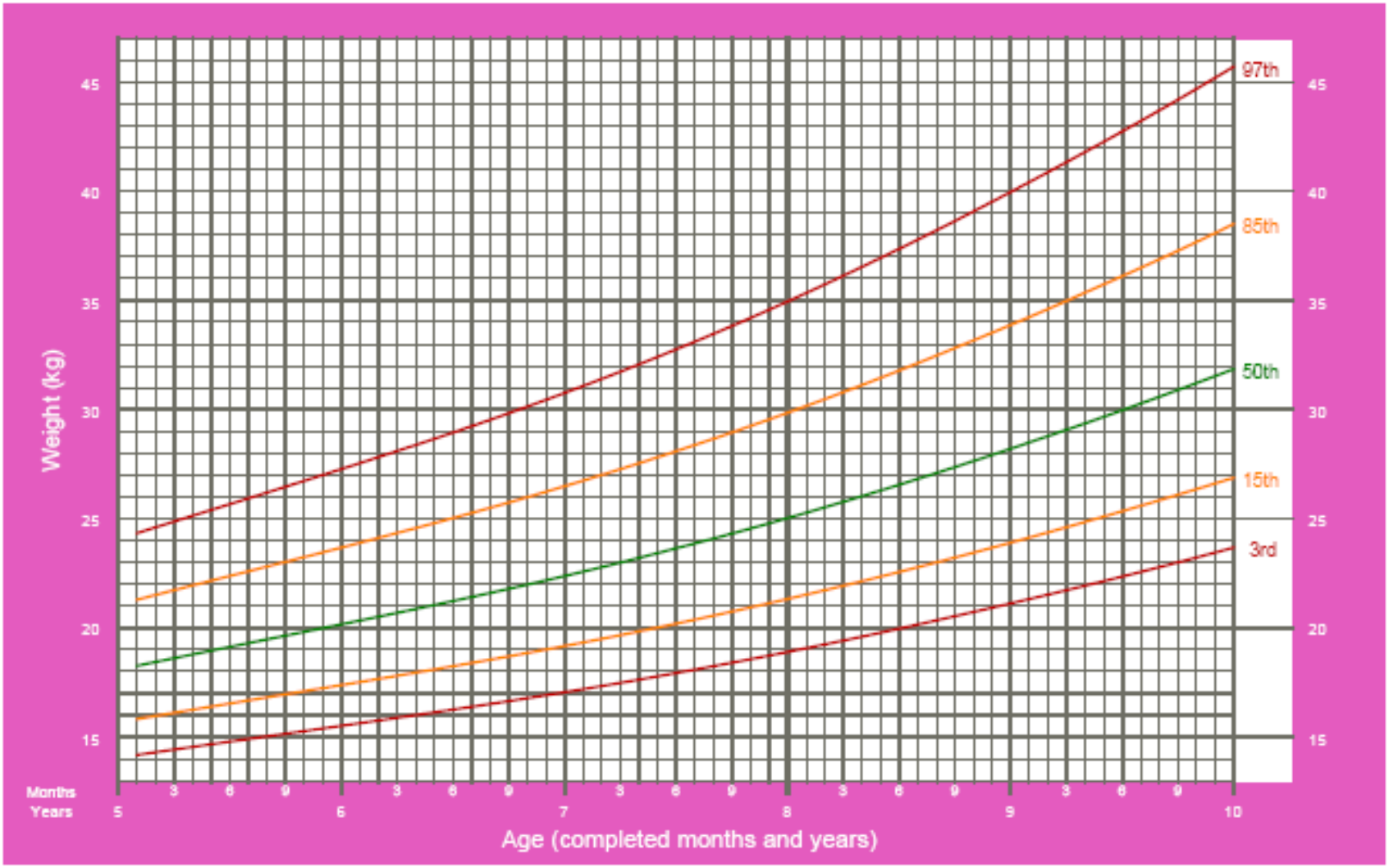
  Boys 175.3 vs 175.8 cm

Zadik et al J ***Ped Gastroenterol Nutr 2003***

Weight-for-age GIRLS

5 to 10 years (percentiles)

World Health Organization

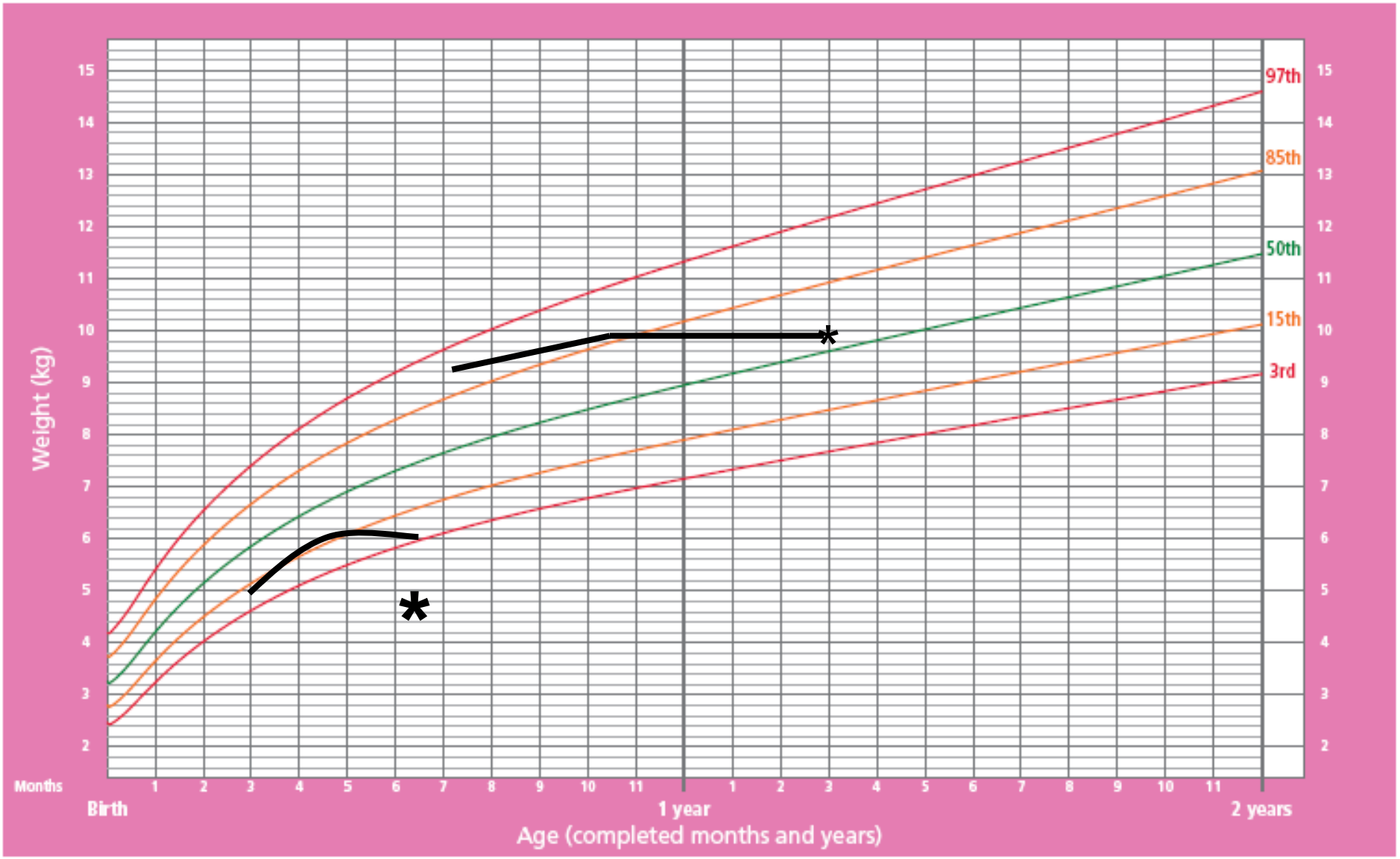


2007 WHO Reference

Weight-for-age GIRLS

Birth to 2 years (percentiles)

World Health Organization



WHO Child Growth Standards

BMI-for-age GIRLS

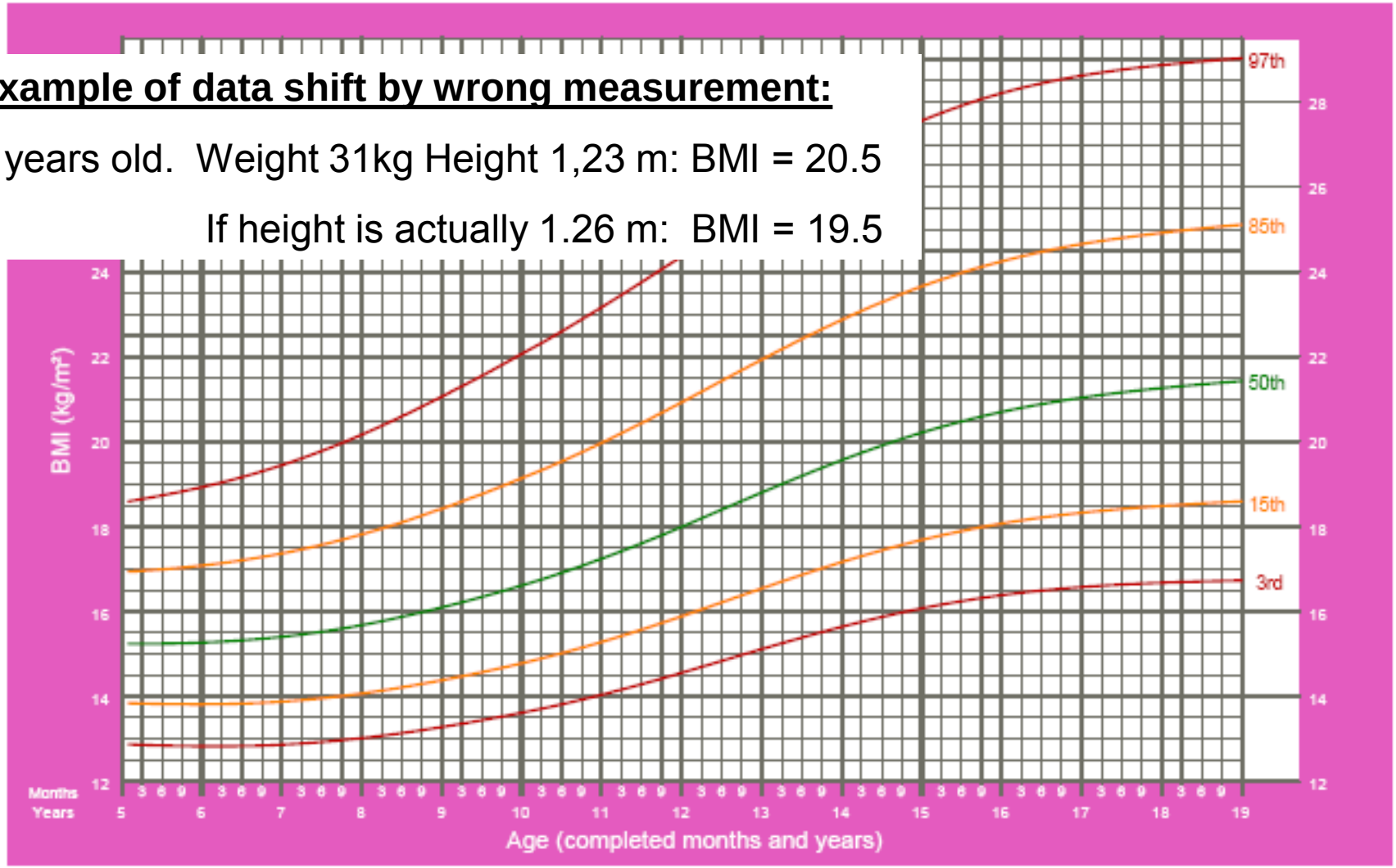
5 to 19 years (percentiles)

World Health Organization

Example of data shift by wrong measurement:

8 years old. Weight 31kg Height 1,23 m: BMI = 20.5

If height is actually 1.26 m: BMI = 19.5

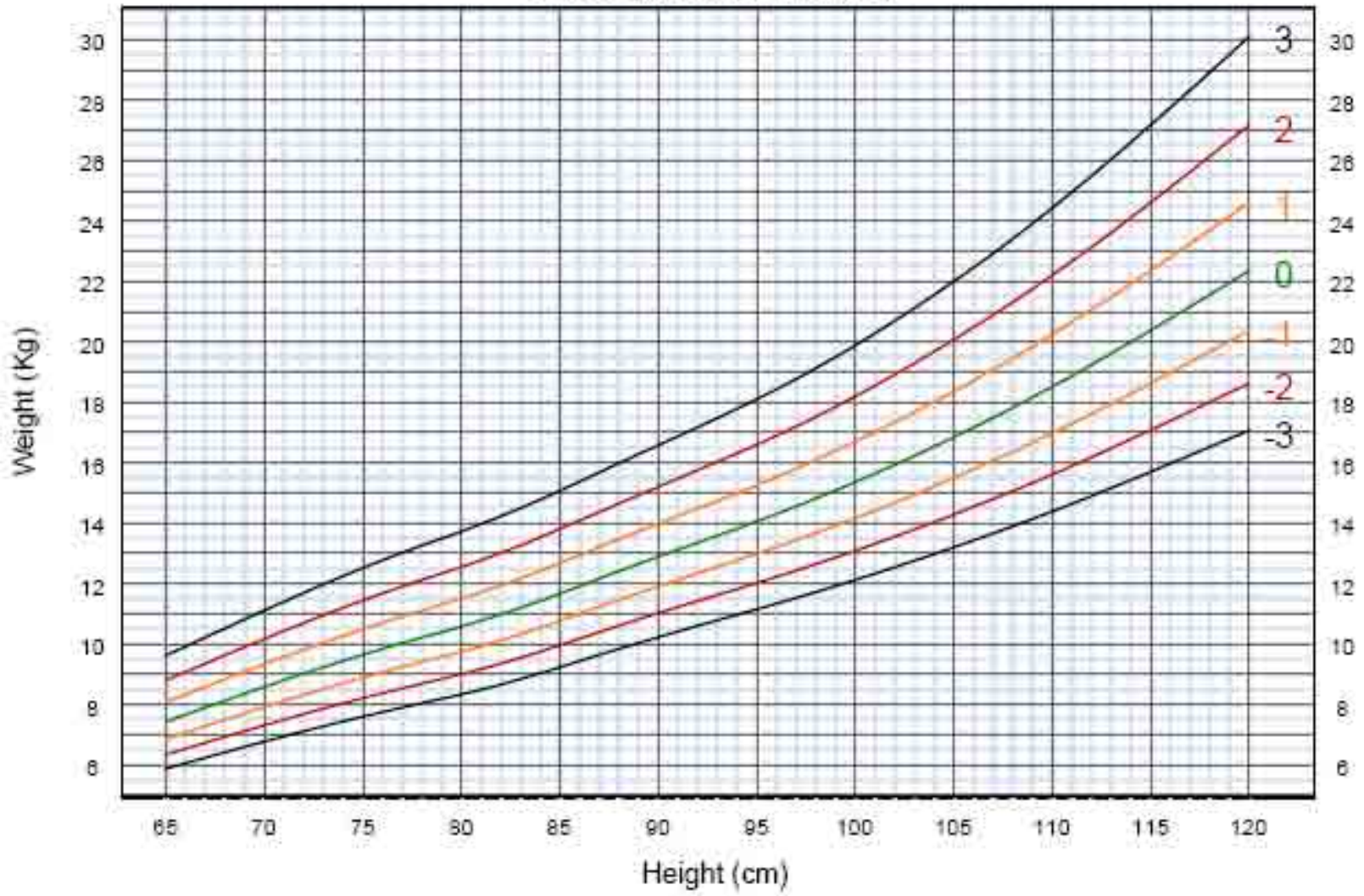


2007 WHO Reference

Remember influence of measurement on derived numbers

Weight-for-height BOYS

2 to 5 years (z-scores)



This **Weight-for-height** chart shows body weight relative to height in comparison to the median (0 line).

- A child whose weight-for-height is above the line 3 is **obese**.
- Above 2 is **overweight**.
- Above 1 shows possible **risk of overweight**.
- Below the line –2 is **wasted**.
- Below –3 is **severely wasted. Refer for urgent specialized care.**

After measurement, what next?

- Measurement does not improve growth
- Interpret the graph
- Action must follow:

Any child with Z score < -3

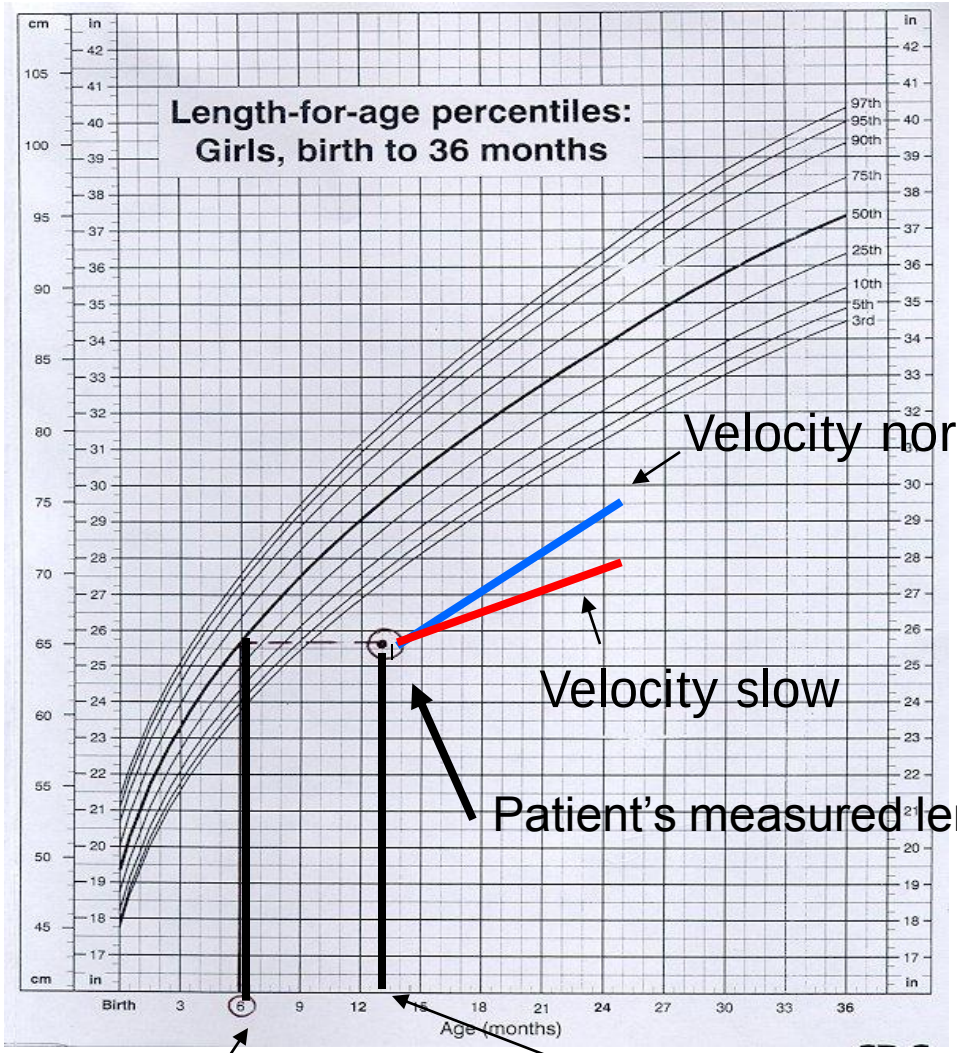
Any child crossing the lines

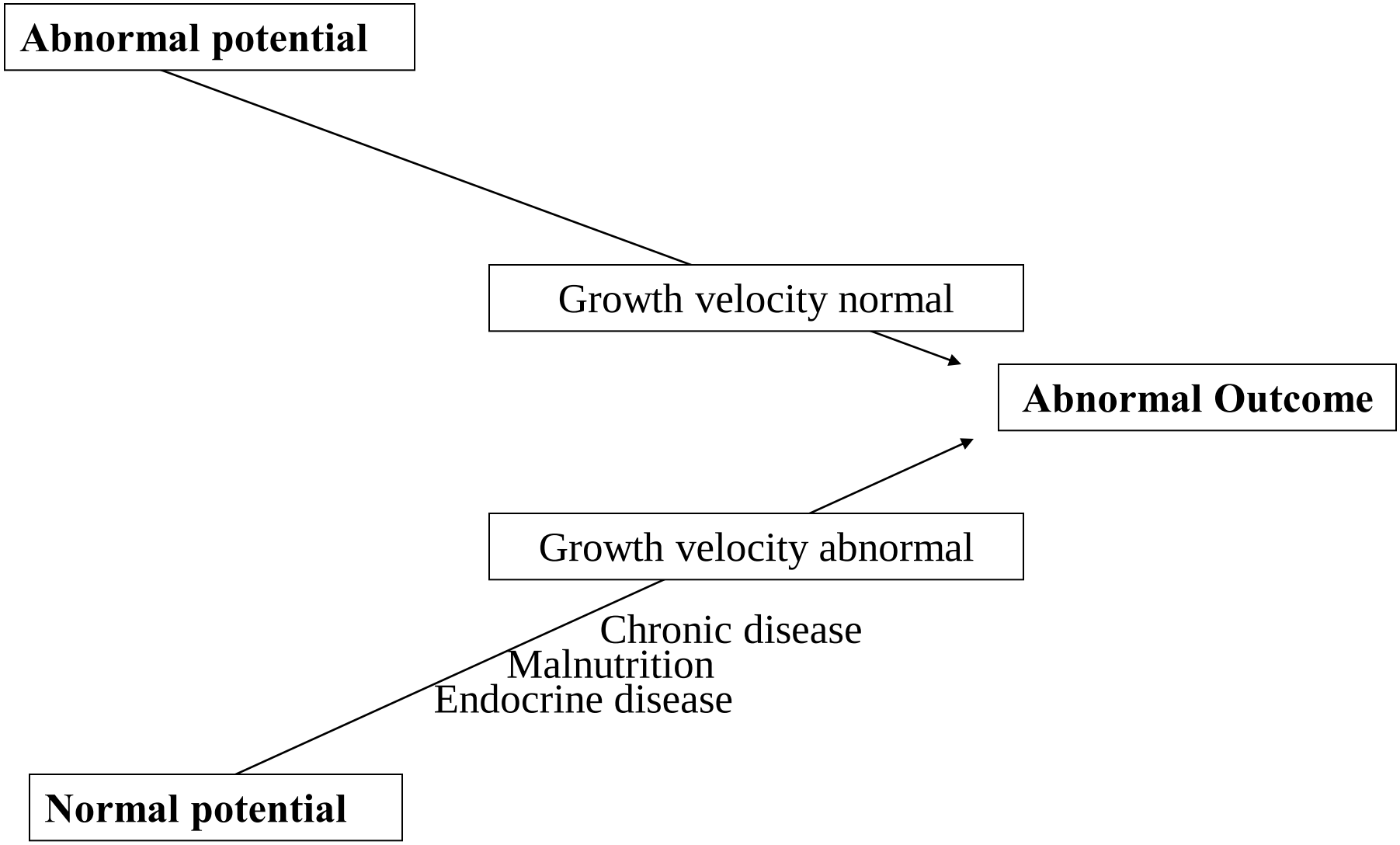
Weight/height discrepancy

Consider wasting

Interpret the growth parameters

Z-score	Growth indicators			
	Length/height-for-age	**Weight-for-age**	**Weight-for-length/height**	**BMI-for-age**
Above 3	*See note 1*	*See note 2*	*Obese*	*Obese*
Above 2			*Overweight*	*Overweight*
Above 1			*Possible risk of overweight (See note 3)*	*Possible risk of overweight (See note 3)*
0 (median)				
Below –1				
Below –2	*Stunted (See note 4)*	*Underweight*	*Wasted*	*Wasted*
Below –3	*Severely stunted (See note 4)*	*Severely underweight (See note 5)*	*Severely wasted*	*Severely wasted*


Length-for-age percentiles:
Girls, birth to 36 months
97th
95th
90th
75th
50th
25th
10th
5th
3rd
cm
in
Birth
3
6
9
12
15
18
21
24
27
30
33
36
Age (months)
Velocity normal
Velocity slow
Patient's measured length
Height age
Chronological age


Abnormal potential
Growth velocity normal
Abnormal Outcome
Growth velocity abnormal
Chronic disease
Malnutrition
Endocrine disease
Normal potential