



Growth Chart: A Passport to child health care a Narrative Review

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ABSTRACT

The assessment of growth by objective anthropometric methods of weight, length/height, and body mass index (BMI) is crucial in child care to assess the nutritional status and for the identification of growth failure. Reference data are central to growth monitoring and they help doctors, health care workers, and policymakers to diagnose undernutrition, overweight and obesity, and other growth-related and endocrine conditions. India is in a phase of nutritional transition and thus it is vital to update growth references regularly.

Key word: growth chart, WHO growth curve. CDC growth curve.

INTRODUCTION

The idea of plotting a child's body measurements on a chart to illustrate their pattern of growth is generally attributed to Count Philibert de Montbeillard (1720-1785), who plotted his son's height every six months from birth to age 18 years, and George Buffon (1707-1788) then published the chart in his *Histoire Naturelle*, thus producing the first height growth curve (Tanner 1962). A growth curve is a powerful graphical tool, as it displays both the size of the child at a series of ages, and at the same time their growth rate or growth velocity over time, based on the slope of the curve. Since its first appearance in the 18th century the use of the growth chart has expanded to include displaying the growth pattern of groups of children as well as individuals, and the chart has become an important tool in child health screening and paediatric clinical workup. India is in a phase of nutritional transition and thus it is vital to update growth references regularly. The previously available growth reference curves in India were based on the data collected by Agarwal et al. in 1989 which were published in 1992 and 1994 and were then adopted by the Indian Academy of Pediatrics for growth monitoring in 2007. World Health Organization (WHO) published new growth standards for children under the age of 5 years in 2006 which are being adopted in many countries including India as a global single standard of childhood growth for the under five children. It is therefore important to review the recent trends in growth monitoring and merits and demerits of the currently available growth references and standards.¹⁻³

DEFINITION

- **Growth:** Increase in the physical size of the body as whole or any of its parts associated with increase in cell number & / or cell size.
- **Growth Chart:** The growth of the child is monitored by recording the weight of the child periodically & plotting against the age, in a specially designed chart called Growth Chart.

DETERMINANTS OF GROWTH & DEVELOPMENT³

- Genetic inheritance
- Nutrition
- Age
- Physical surrounding
- Psychological factors
- Infection & parasites
- Economic factors

ASSESSMENT OF GROWTH

- The assessment of growth may be longitudinal or cross sectional.
- Longitudinal assessment of growth entails measuring the same child at regular intervals.
- Cross sectional comparisons involve large number of children of same age.
- Basic growth assessment involves measuring a child’s weight and length or height comparing these measurements to growth standards.

PURPOSE OF GROWTH ASSESSMENT⁴

- The purpose is to determine whether a child is growing —normally orhas a growth problem or trend towards a growth problem that should be addressed.

METHODS OF NUTRITIONAL ASSESSMENT

- Are not mutually exclusive; on the contrary, they are complementary to each other

Direct methods	Indirect methods
Clinical methods	Assessment of dietary Intake(Diet Survey)
Anthropometry	Vital statistics
Biochemical methods	Ecological studies
Functional assessment	
Biophysical and radiological examination	

NORMAL GROWTH

- A normal child may be defined as one whose characteristics fall within the range of measurement accepted as normal for the majority of children in the same age group.

ANTHROPOMETRY

- Can reflect changes in morphological variation due to inappropriate food intake or malnutrition
- There is no single permanent standard.

- Uniform growth pattern is not seen to occur equally all over the world and also in subsequent generations⁵

COMPONENTS OF ANTHROPOMETRIC ASSESSMENT

Weight-for-age

- Normal variation in weight at a given age is wide.
- Ideally what is important is careful measurements at repeated intervals:-
 - ✓ Every month, from birth to 1 year
 - ✓ Every 2 months during the second year
 - ✓ Every 3 months thereafter upto 5 years of age.
- This age group is at the greatest risk from growth faltering.
- By comparing the measurements with reference standards of weight of children of the same age, the trend of growth becomes obvious.
- This is best done on growth chart. Serial weighing is also useful to interpret the progress of growth when the age of the child is not known.⁶

Height(Length)-for-age

- The maximum growth potential of an individual is decided by hereditary factors.
- Among the environmental factors, the most important being nutrition and morbidity.
- Is considered an index of chronic or long duration malnutrition.

Weight-for-height

- Weight-for-height is now considered more important than weight alone.
- It helps to determine whether a child is within range of "normal" weight for his height

Mid-arm Circumference

- Yields a relatively reliable estimation of the body's muscle mass,
- The reduction of which is one of the most striking mechanisms by which the body adjusts to inadequate energy intakes .
- Arm circumference cannot be used before the age of one year
- between ages one and five years, it hardly varies .⁶

Scales of Measurements

- Z scores
- Percentiles
- Percent of median⁷

1. Z- Score or standard deviation score

- The deviation of the value for an individual from the median value of the reference population, divided by the standard Deviation for the reference population

$$Z\text{- Score} = \frac{(\text{Observed value}) - (\text{Median reference value})}{\text{Standard deviation of reference population}}$$

- A fixed Z score interval implies a fixed height or weight difference for children of a given age .
- Advantage:- Allows mean and SD calculation for a group of Z score in population based applications

2. Percentile

- The rank position of an individual on a given reference distribution, stated in terms of what percentage of the group the individual equals or exceeds .
- Eg. A child of a given age whose weight falls in the 10th percentile weighs the same or more than 10% of the reference population of children of same age
- Summary statistics not possible
- Towards the extremes of the reference distribution there is little change in percentile values, when there is infact substantial change in weight or height
- Commonly used -3,-2 and -1 Z scores are respectively the 0.13th , 2.28th and 15.8th percentiles and the 1st ,3rd and 10th percentiles correspond to, respectively, the -2.33,-1.88,and -1.29 Z scores.

3. Percent of median

- Ratio of a measured value in the individual, for instance weight, to the median value of the reference data for the same age or height, expressed as a percentage.

Main disadvantage-lack of exact correspondence with a fixed point of distribution across age and wt status

Eg. Depending on the child's age, 80% of the median weight for age might be above or below -2Z score; in terms of health, it reflects in different classification of risk.⁷

- Cut off points for percent of median are different for the different anthropometric indices.

USES OF GROWTH CHART

- Diagnostic tool-To identify high risk children.
- Planning and policy making
- Education tool for educating mothers
- Tool for action helps in type of intervention that is needed
- Evaluation of effectiveness of corrective measure and impact of a programme of special interventions for improving Childs growth and development
- Tool for teaching.
- Calculate drug dosage.⁸

HOW TO MEASURE

- At the first visit the child's name, date of birth and other details should be entered on the growth chart and the chart should be explained to the parents. This ensures that they are interested in it and are more likely to keep it properly and bring it at each visit. The growth chart should be kept with the parents in a plastic sleeve.
- Measure the parents and make a note of their heights on the chart. Calculate the child's target height and plot it at 18 years and mark it with an arrow on the growth chart. This represents the child's projected height and his present height centile can be judged by tracing a line backward from this target height to child's current height. The target range is produced by plotting two points 8 cms above and below the target height and this represents the 3rd and the 97th centile for that child. Taking those two points above and below the target height 97th and 3rd centiles are constructed by tracing lines backwards to match the current age⁹⁻¹¹
- All the points on the growth chart should be marked only as dots and not circles around the dot.
- The height and weight should be recorded (and head circumference till 3 years) and plotted on the chart. At all subsequent visits join the dot up to the previous dot.
- Remind parents of the time for the next measurement.

CDC GROWTH CHART

- The 2000 CDC growth charts represent the revised version of the 1977 NCHS growth charts
- The revised growth charts consist of 16 charts (8 for boys and 8 for girls)
- introduction of two new body mass index- for-age (BMI-for-age) charts for boys and for girls, ages 2 to 20 years.¹²

Data collected from

1. National Health and Nutrition Examination Surveys (NHANES),
 2. National Natality Files
 3. Natality Files in Wisconsin and Missouri,
 4. The CDC Pediatric Nutrition Surveillance System,
 5. The Fels Research Institute child growth study
- The primary source of data for the infant charts up to age 6 months was NHANES III.

CDC 2000 GROWTH CHART NEW FEATURES

- Addition of BMI for age charts: 2 – 20 years
- Addition of 85th centile on BMI for age & wt for stature charts
- Addition of 3rd & 97th centiles
- Limits of length & stature extended on wt for length & wt for stature charts
- Smoothed percentile curves & Z scores
- Correction of disjunction that occurred between 24 & 36 months when switching from length to stature in NCHS charts¹²
- Considering the drawbacks of 1977 NCHS international growth reference in terms of age restriction, distribution range and ineffectiveness of assessing childhood obesity, WHO proceeded to reconstruct the NCHS growth reference to develop a single international growth reference in 2007 for school age children from 5–19 years of age, based on the original NCHS statistics data (5–24 years).

WHO GROWTH CHART²

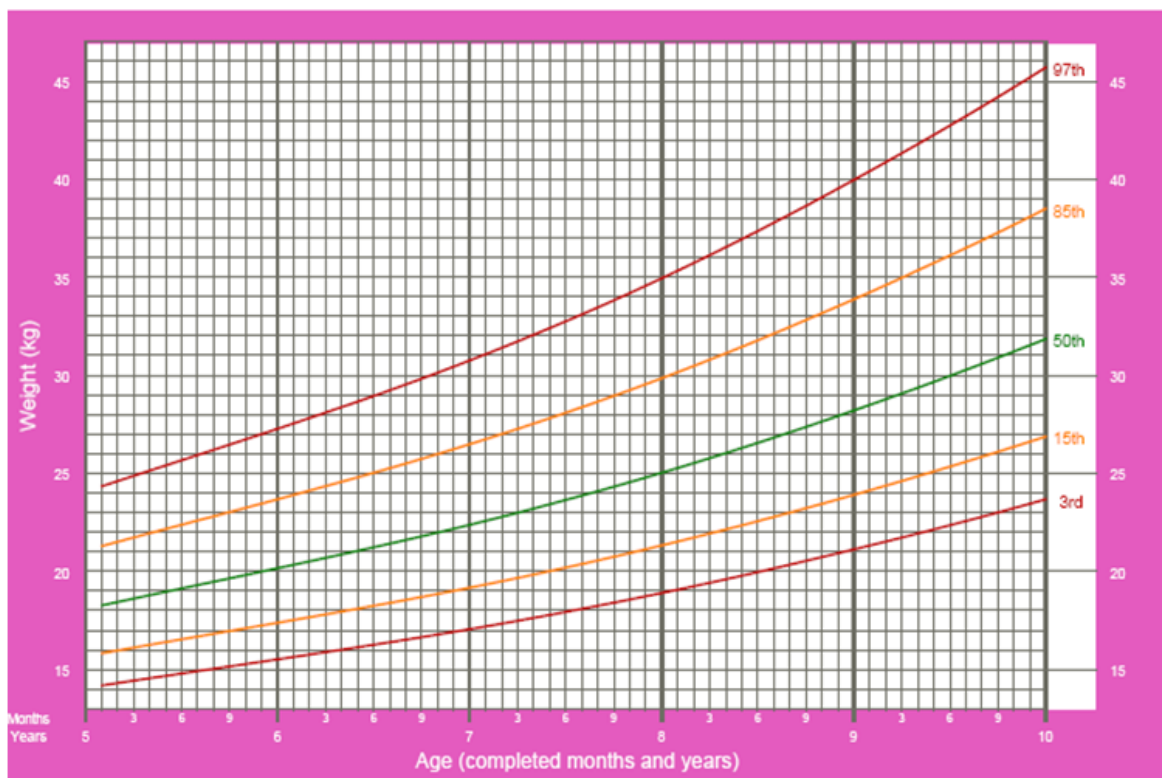
- Multicentric Growth Reference Study (MGRS)-
- Participating countries include Brazil, Ghana, India, Norway, Oman, and USA.
- Data collected by trained staff using a common protocol
- Sample selected from communities where there were no environmental constraints to growth.
- The new growth reference is based on breastfeeding as the biological norm.
- Measurements include weight/age, height/age, and weight/height. Data on BMI was generated for children under 5 for the 1st time.
- In 1993 the WHO took a comprehensive review & concluded that NCHS growth curve recommended during 1970, did not adequately represent early childhood.

BASICS OF GROWTH CHART

- Consists of X axis which is usually in years or months and y axis that changes according to the reference e.g. cm, inches, kg, kg/m².
- the x axis is usually divided into 12 equal parts (months) for each year. Standard growth chart has 7 percentile lines and include 3, 10, 25, 50, 75, and 97 percentiles.
- The correlation between Z scores and percentiles can be confusing and in recent WHO MGRS study these are tabulated below for clarity.¹³

Weight-for-age GIRLS

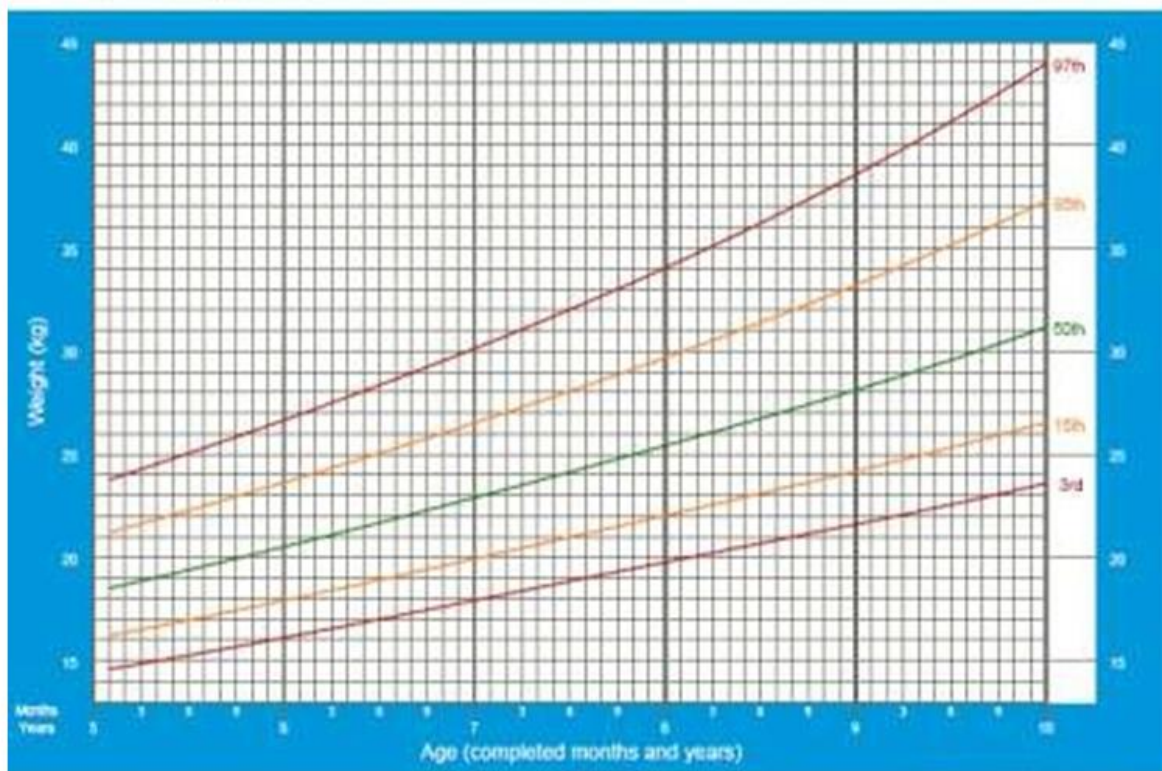
5 to 10 years (percentiles)



2007 WHO Reference

Weight-for-age BOYS

5 to 10 years (percentiles)



2007 WHO Reference

ADVANTAGES

- Seen as ‘gold standard’ of growth charts in terms of promoting good health outcomes, including across cultures.
- Establishes breastfeeding as the biological norm.
- More suitable to the aboriginal population as the infants, especially in remote communities, are predominantly breastfed.
- Have greater capacity to assist the early identification of development of overweight
- Advantage of having a growth standard such as WHO 2006 charts is that children of all countries, races, ethnicity can be compared against a single standard thus assessment becomes more objective and easy to compare.^{14,15}

LIMITATIONS OF GROWTH CHART

- It does not reflect current feeding practices
- The rapid gain demonstrated in breastfed infants first six months may not be appropriate for all breastfed babies i.e. may indirectly discourage exclusive breast feeding.
- Slower than the expected growth rates may be interpreted as neglect especially in aboriginal communities.
- The disadvantage of using charts such as these is that they are likely to over diagnose underweight and stunting in a large number of apparently normal children in the developing countries such as India.

COMPARISON OF WHO GROWTH STANDARDS AND CDC GROWTH REFERENCE

Comparison	WHO Growth Chart	CDC Growth Chart
Studied population	Breastfed infants and toddlers	Breastfed and formula fed infants and toddlers
Growth pattern	How healthy children SHOULD GROW in ideal conditions	How certain groups of children HAVE GROWN in the past
Concept of growth	A STANDARD by which all children should be compared	A REFERENCE does not imply that pattern of growth is optimal

GROWTH CHART RECOMMENDATIONS FOR HEALTH CARE PROVIDERS

CDC recommends that health care providers:

- Use the WHO growth charts for infants and children 0 to 2 years of age
- Use the CDC growth charts for children ages 2 to 20 years

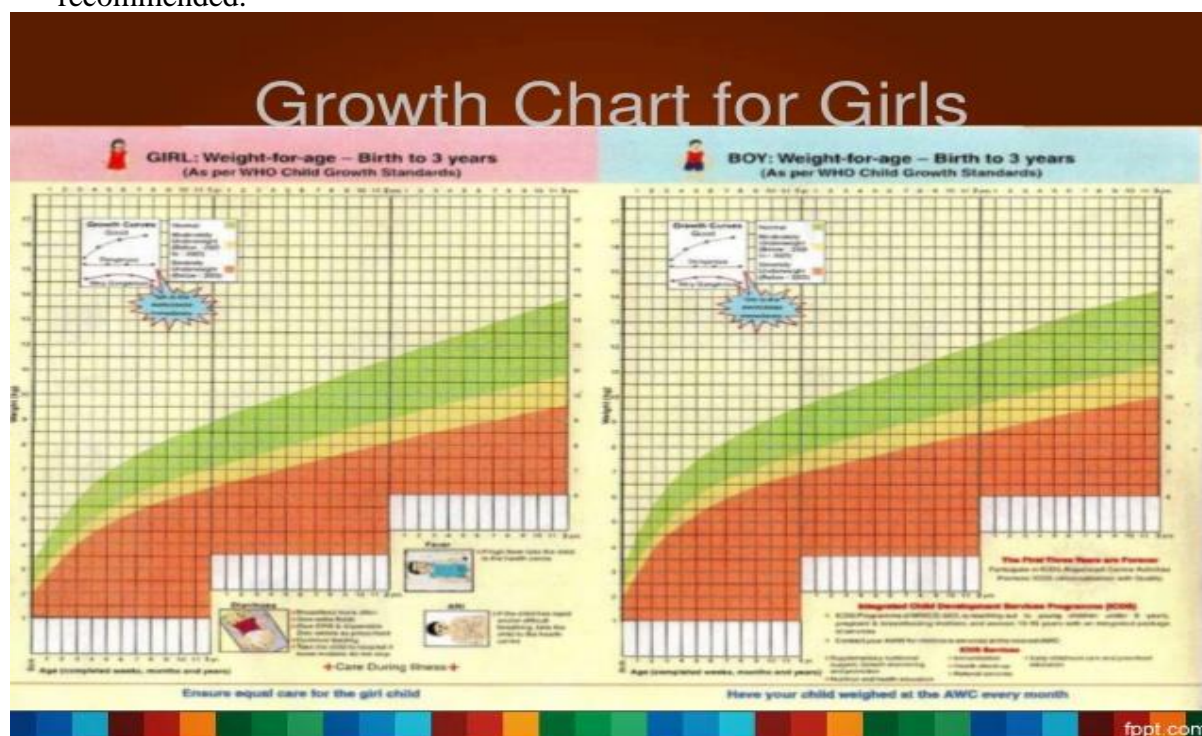
WHY USE WHO CHART IN LESS THAN 2 YEARS

- The WHO standards establish growth of the breastfed infant as the norm for growth
- The WHO standards provide a better description of physiological growth in infancy
- The WHO standards are based on a high-quality study designed explicitly for creating growth charts.¹⁶

GROWTH CHART USED IN INDIA

- The ICMR undertook a nationwide cross sectional study during 1956-1965 to establish Indian reference charts. Irrelevant now as they were done on lower socio-economic class.
- The growth charts compiled by Agarwal et al were based on affluent urban children from all major zones of India measured 1989-1991. The data is now 20 years old and irrelevant now.

- In 2010-2011 Khadilkar et al have published the growth charts on affluent children 5-18 years and have also compared the growth of 2-5 years old Indian children with the new WHO growth charts. These are the most modern national growth references available now at present.
- India has adopted the new WHO Child growth standards (2006) in February 2009
- The standards are available for both boys & girls below 5 years of age.
- A joint “Mother & Child Protection Card” has been developed which provides space for recording the family identification & registration, birth record, pregnancy record, care during pregnancy details about immunization, registration under Janani Suraksha Yojna.¹⁷
- Although the world’s children appear to follow a similar growth pattern, still there are variations due to ethnic, geographical, and regional factors giving different rates of maturation and adult stature.
- The Indian Council for Medical Research (ICMR) undertook a nationwide cross sectional study during 1956 and 1965 to establish Indian reference charts. The measurements were made on children of the lower socio-economic class and hence cannot be used as a reference standard.
- These charts provide information on growth from birth to 18 years (unlike the new WHO standards providing data up to 5 years). Thus, in the present circumstances, WHO charts remain best option for growth monitoring in Indian children and are recommended for use by the Growth Monitoring Guidelines Consensus Meeting of the IAP . At the community worker level, the continued use of the Government charts for monitoring of weight is recommended.¹⁸



NEW 2007 AFFLUENT INDIA GROWTH CHART

- THE NEED FOR NEW CHARTS- previously available growth reference curves in india are almost 2 decades old and WHO recommends that each country should update its growth references every decade and hence new growth references were produced in 2009.
- DATA COLLECTION-The IAP divides India into 5 zones-north, south, east, west and central.

- the nutritionally well areas were identified based on per capita income of cities.
- The differences between zones were not significant
- Data collection lasted from June 2007 to January 2008.¹⁷

IAP GUIDELINES FOR GROWTH MONITORING

- Weight monitoring at monthly in 1st year every 2 months during 2nd year every 3 months up to 6 years

RECOMMENDED PARAMETER

ž Birth to 3 years

Immunization contacts at birth, 6, 10 and 14 weeks, 9 months, 15-18 months and thereafter every 6 months

ž 4 to 8 years

height and weight be measured 6 monthly BMI, PL and SMR should be assessed yearly from 6 years of age.

ž 9-18 years

height, weight, BMI and SMR be assessed yearly¹⁴

PUBLIC HEALTH DENTISTRY ASPECT

- Growth chart is used
- Primarily to identify children with growth deviation and diseases and conditions that manifest through abnormal growth.
- Secondarily to discuss health promotion related to feeding, hygiene, immunisation and other aspects, education of parents to allay their anxiety about their child's growth also to sensitize health care workers to use growth charts.

CONCLUSION

- No existing Growth chart is a perfect match in Indian context. The CDC 2000 and WHO 2006 growth charts both have their benefits and Limitations—Indian breast feeding practices, birth weight, multicultural population mix.
- CDC recommends
 - The WHO growth standard charts should be used for children younger than 2.
 - The CDC 2000 growth reference charts should be used for children aged 2 through 19 years, because these charts can be used continuously up to age 20
- Growth assessments that are not supported by appropriate response programmes are not effective in improving child health.

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