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Growth pattern in Indian children

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Abstract

Growth of children is a continuous process commencing at the conception and progressing at a varying pace during stage of growth. The process of 'Growth' is accompanied with increase in body size and or mass at varying rates, Importantly Boys and girls grow differently. Growth monitoring assists child health practitioners to assess whether a child is growing as expected or if there are potential growth problems. Monitoring a child's growth also provides opportunities to parents for guidance to support and promote healthy growth and development. The childhood under nutrition for children under five years of age is measured in terms of stunting and underweight. Growth charts are used to monitor the growth of infants and children. These graphs for weight for height for boys and girls have been developed by WHO, National Bodies and individual experts working on the subject. The use of WHO growth data as standard over diagnoses- underweight and stunted children for India. Country standard may be more ideal for assessing growth than the WHO growth standards. Thus, there is need to use Indian references growth data to assess the exact extent of under nutrition and stunting. Importantly, 2015 IAP growth chart constructed on studies published by different authors remains unsuitable to detect early overweight and obesity and the same time over estimate under nutrition. The growth charts for children under five years of age developed by Agarwal et al are appropriate for use in India. For children 5 to 18 years of age, the ICMR growth data will continue to serve as the baseline reference data for accessing growth, seeing secular trend in height and percentage of children becoming overweight and obese in India. The ICMR data are also by Agarwal et al.(1991). It is important to mention that Birth to 5 yr study was funded by the NFI and 5-18 yr study by the ICMR.

Keywords: Body Mass Index, Growth Chart, Obesity, Stunting, Under nutrition, Z score

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1. Introduction

The anthropometeric measurements which depict physical growth are sensitive indicators of the health of a population. Infact it has been rightly said that measurement of children growth in a society acts as a barometer of overall national well being. It has been a common observation that Japanese, Indian, Philippine or Saudi Arabia children are smaller

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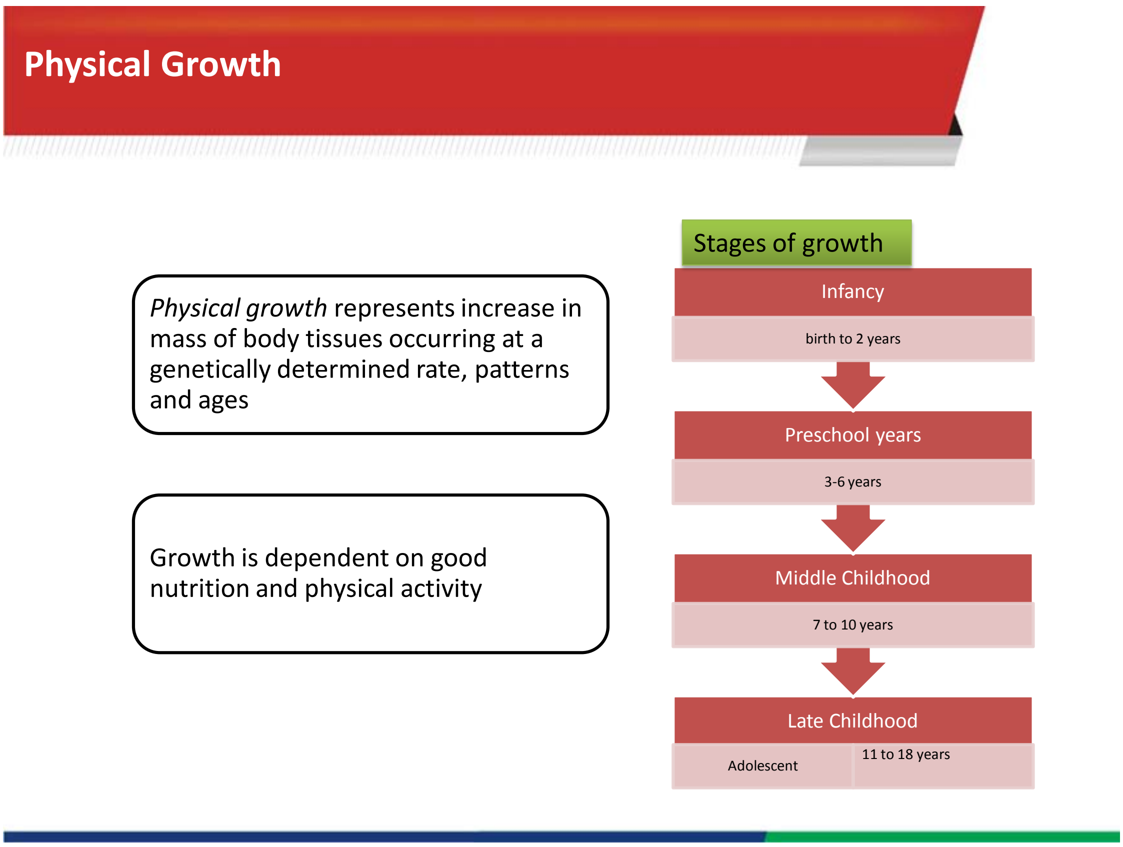
than their age peers of African, American and European countries. These differences in child population are reflected in differences seen in adult population. The deviate continues for relative contribution(s) of environmental factors (socio-economic status, physical activity, psychological stress or nutritional status) are directly and indirectly related with nutrition.
The differences in size start right from birth. The birth weight of black babies is lower than babies of American or European origin at comparable socioeconomic index. These differences in size at birth between blacks and whites are soon reversed by 1-2 years of age as black infants reach similar or have higher weight and length than whites in the same socioeconomic group. Indian newborns in London are 300 g lighter than whites.

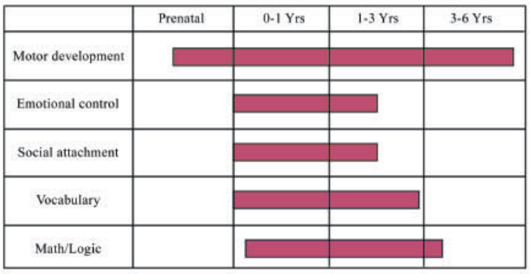
Growth is a continuous process commencing at conception and progressing at a varying pace till its completion about 2 decades later, with closure of epiphysis. The process of 'Growth' is accompanied with increase in body size and or mass at varying rates. It is multi factorial and complex, still remarkably predictable. Boys and girls grow differently and each child has his or her distinct growth pattern.
To summarize:

- Growth is a fundamental characteristic of childhood
- Despite being influenced by many factors, it remains remarkably predictable
- Normal growth is an indicator of optimum health
- Deviation from the normal pattern is indicative of a pathological process
- Periodic assessment facilitates early detection of growth faltering which may be the first manifestation of under/over nutrition, infection /disease.

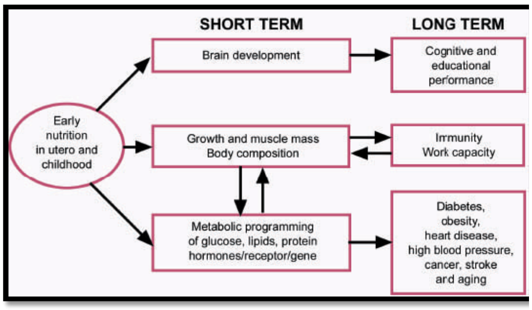


Child’s Growth and Development: Link with Nutrition

Timeline of growth and development



Short and long term consequences of nutritional deficiencies



1. UNICEF. Early Childhood Development: The key to a full and productive life. Available at: www.unicef.org/dprk/ecd.pd accessed on 31 January 2014.

Growth pattern of different body systems

- **General body growth-** *During 1st year of life 25 cm; 2nd year* = *12.5* cm; 3rd year = 7.5-10 cm.
- 7cm/year at 3-4 yrs. 5 yr onwards= 5cm/yr until puberty.
- **Brain growth**-At birth, the brain of the infant is 25% of the adult size. At the age of one year, the brain has grown to 75% of its adult size and to 80% by age three, reaching 90% by age seven.
- **Lymphoid tissue-** during middle childhood maximum 8-9 yr. reaching > 180%.
- **Reproductive organs-** puberty by 9-11 yr in girls and 11-14 yr in boys..

Puberty encompasses-

Somatic Growth & Sexual development-

1. Adolescent growth spurt,
2. Development of secondary sexual characteristics.
3. Attainment of fertility.
4. Establishment of individual sexual identity.
5. Timing for Puberty onset has wide variability-
6. Girls- 9-12 years and Boys- 11-14 years of age.

Adolescent Growth Spurt-

1. Begins distally with enlargement of Hand and Feet, followed by the Arms & Legs and finally by the Trunk and Chest.
2. Larynx, pharynx and lungs—Voice
3. Androgens- a) Sebaceous glands- Acne, b) Optic globe-myopia and c) dental- jaw growth, loss of deciduous teeth eruption of permanent cuspids, premolars, and finally molars.

Ethnic & Sibling variability in the onset and duration of Puberty-

1. Ethnic- American Blacks enter puberty earlier than Whites: *Breast Stage-2* at 8 years of age **Blacks 48%(**average age 8.8yr; PH- 8.7yr); **Whites-only 15%(**Av age 9.9yr; PH 10.7 yr). However, “Menarche” same time 12.2yr and 12.8yr, respectively.
2. Besides racial “Onset of Puberty” is different in an individual child, as well as in case of siblings.

Table 1. Showing comparative figures for initiation of sexual development in US and Indian Children.

Wu et al 2002; USA[1]	N=1168	Age = 8-16 yr	SMR= B2 Afro-American 9.5 yr Whites 10.3 yr	Menarche yr 12.2 yr 12.6 yr	Pubic hair -2 9.5 yr 10.6 yr	GIRLS
Agarwal et al 1992 INDIA[2]	N= 1291	8-17 yr	10.2 yr	12.6 yr	22% had hair at B2.	GIRLS
Herman-Giddens et al 2001 USA[3]	2114	8-19 yr	Afro-American 9.5yr Whites 10.1 yr	-	11.2 yr 12.0 yr	Boys
Agarwal et al 1992 INDIA[2]	1779	8-18 yr	11.3 yr	-	59.3%	Boys

2. Growth assessment charts- *Birth to 5 years of age*

Growth monitoring assists child health practitioners assess whether a child is growing as expected or if there are potential growth problems. Disturbances in health and nutrition in infants and young children, almost always affect their growth. Growth measurements are plotted on an age and gender appropriate growth chart to show how the child is growing. Monitoring a child’s growth also provides opportunities to give parents anticipatory guidance to support the development of healthy lifestyles to promote healthy growth and development. Which charts should be used to monitor the growth of infants and children?

The data on affluent Indian children were collected during 1985-1987 (Nutrition Foundation of India -NFI)[4] from Birth to 5 years (7 states/ cities- Banglore, Bombay, Calcutta, Delhi, Kota, Ludhiana and Varanasi), only full term with birth weight $\geq$2500 g (boys 433 and girls 346) were followed during first year of life at 3, 6, 9 and 12 months of age with minimum of 3 reading for every infant (cohort-I). Children could enter the study anytime but measurements were recorded on fixed age points. In cohort-II, from 12 months to 5 years (children of cohort-I also continued) of age 1011 boys and 874 girls were followed on their birthday and 6 monthly with minimum of 3 measurements for each child up to 72 months of age [5]. The data collection and analysis used the Linked-cross sectional study design for determining norms and growth rates(Rao and Rao 1966)[6] Children had received exclusive breast milk for 3-4 months of life in cohort I & II (as prevalent in those years). Before pooling data from centers variation was calculated from the 50th centile of the length/height pooled data, which was < 3%. The smoothed cubic spline least square method percentiles were calculated (Fig 1 & 2)[4,5].

Fig 1. Height, Weight & Head Circumference Percentile Curves (Boys 0-5 years)

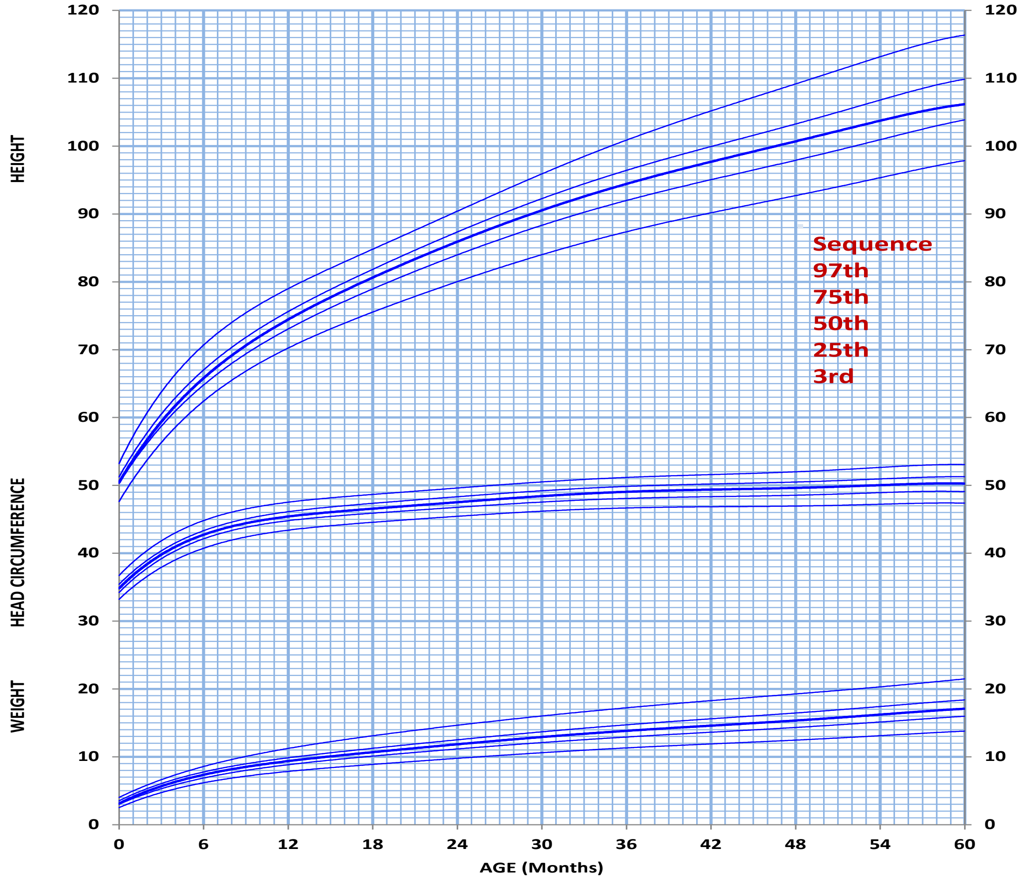
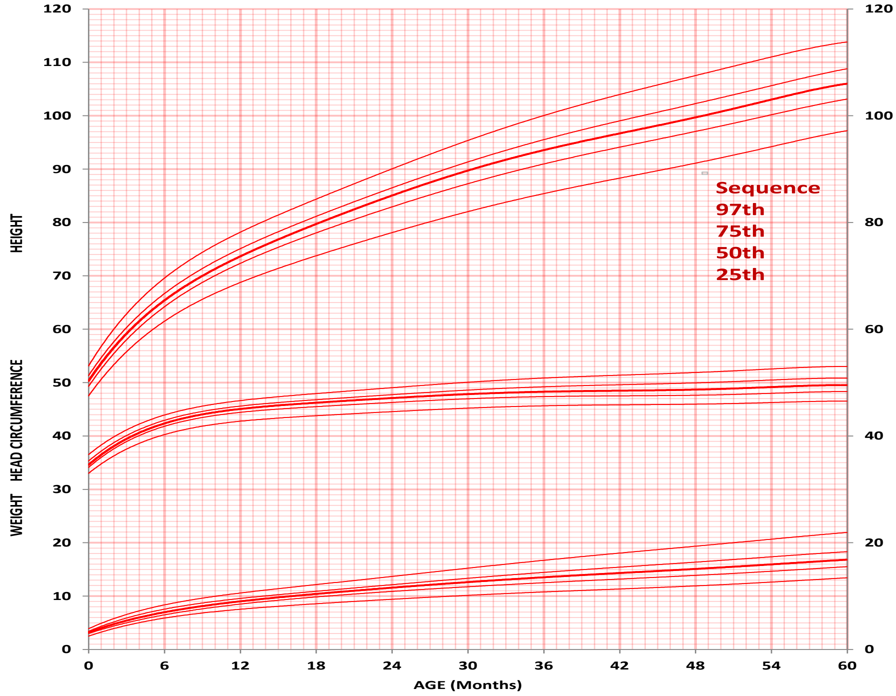


Fig 2. Height, Weight & Head Circumference Percentile Curves (Girls 0-5 years)



The WHO growth data[7] , were collected from south Delhi area, and after statistical treatment merged in the International data to provide the available growth **standards** from birth to 5 years of age. The WHO growth standards aim to represent growth as it occurs worldwide, these chart depart from the growth reference model in several ways. Children from six countries (Brazil, Ghana, India, Norway, Oman, USA) provided the data measurements, which were not representative of their country of residence, and were selected on the basis of socio-demographic and child's nutrition as per WHO guidelines. Although selection criteria were similarly applied in all six countries but exclusion of children was unproportionate. Further overweight children to height were also excluded. The growth chart developed by this 'prescriptive' method is accepted as standard for optimal growth.

3. Wasting and stunting

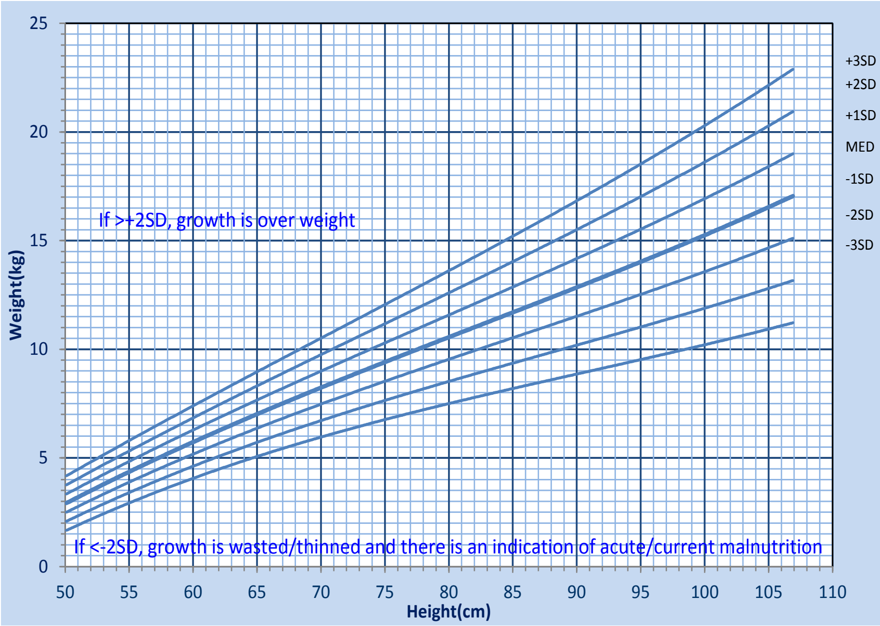
The childhood under nutrition in under five years of age in terms of **Stunting** (reduced length—chronic under nutrition currently remains-48%) and **underweight** (currently 43%) and **wasting** (reduced weight for height - currently 20%). These figures have been assessed using the American weight and height data (CDC) or World Health organization (WHO) growth curves 2006 (Birth to 5 years) as accepted by the Government of India (Ministries of Health FW and Social welfare- Maternal child Welfare/ HRD) on recommendations of the UNICEF.

- A **stunted** child has a height-for-age z-score that is at least 2 standard deviations (SD) below the median for the WHO Child Growth Standards.
- A **wasted** child has a weight-for-height z-score that is at least 2 SD below the median for the WHO Child Growth Standards.

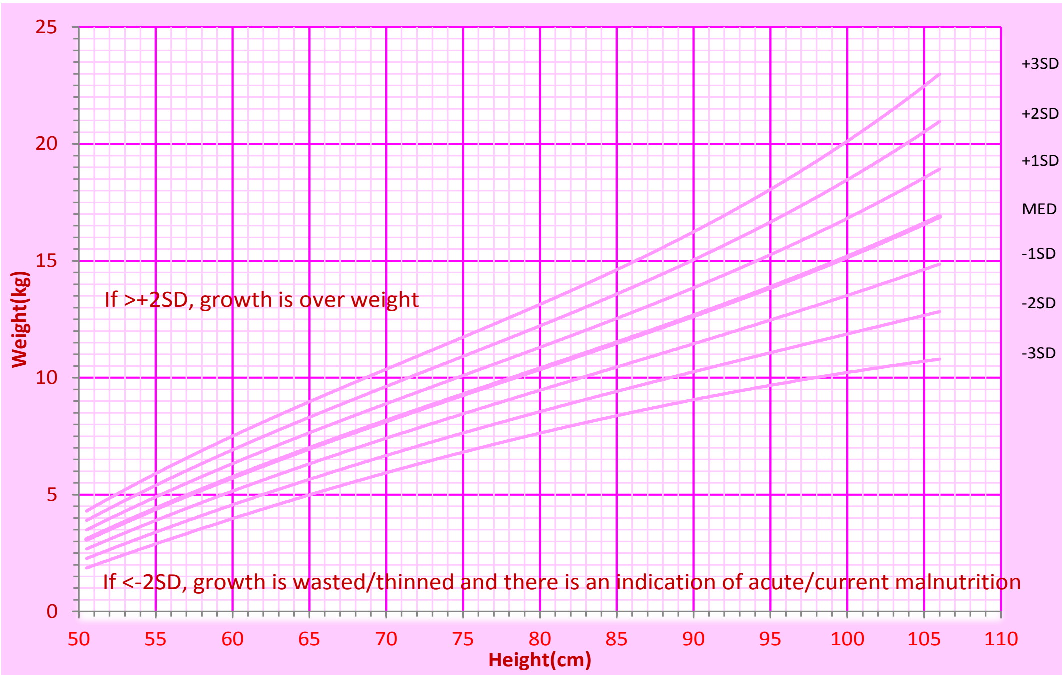
This was and still continues to be beneficial to the concerned ministries and UNICEF to show that Indian children are having acute as well as chronic under nutrition in large numbers and Government of India should make large fund allocations to control and treat.

The current use of **WHO growth data as standard** over diagnoses – Underweight and Stunted children. There is need to use Indian reference growth data (as reference data show how children are growing in time and place) to assess the exact extent of under nutrition and stunting. These graphs for weight for height for boys and girls are given below for calculating stunting and wasting.

Boys



Girls



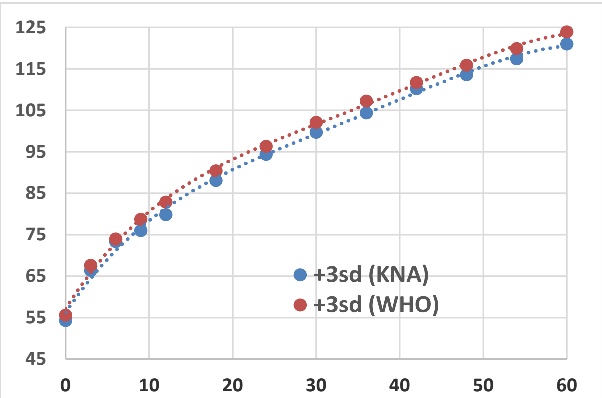
4. Comparison of Agarwal growth data with the WHO (MGRS) standards

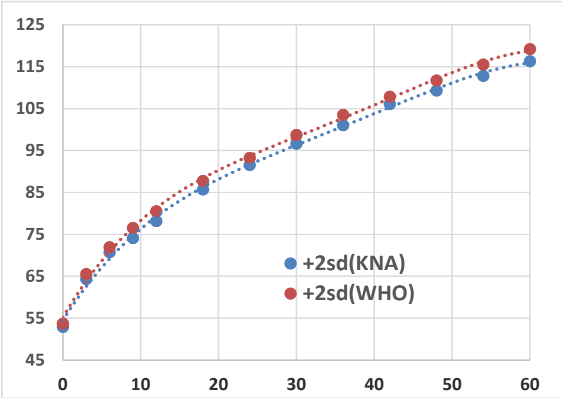
In a recent study" Worldwide variation in human growth and the WHO growth standards: a systemic review" by Natale V and Rajgopalan A BMJ Open 2014; 13th March[8]. WHO assumed that all economically advantaged children who were breastfed as infants grow similarly? As a result, a single set of growth charts can be used to judge growth in any child regardless of race or ethnicity. Natale and Rajgopalan compared mean heights, weights and head circumferences from a variety of studies with the WHO's data. They compared WHO (Multicenter Growth Reference study- MGRS[6]) with data from 55 countries or ethnic groups. These study countries included India (data from Agarwal & Agarwal 1994)[4,5], Norway and the USA as these countries had participated in the MGRS study. For height Indian children were below - 0.5 SD at more than 3 age points (Birth to 5 years of age). In a large German study 2011 by Rosario et al.[9], found that means for girls and boys were taller being at 62nd and 60th MGRS centiles respectively, this made them to use the *national data as standards* instead of MGRS. To conclude Europeans were generally above 0.5 SD and the Indians were below – 0.5 SD as compared to the WHO standard. **Thus WHO growth curve may under indicate short stature in slightly taller European populations and over indicate it in short populations Asian Indians. It is what gives higher values for stunting in our < 5 year children.** Similarly using WHO charts for weight will calculate more number of underweight children. Further the MGRS head circumference means may put many children at risk of misdiagnosis of micro/macro cephalic.

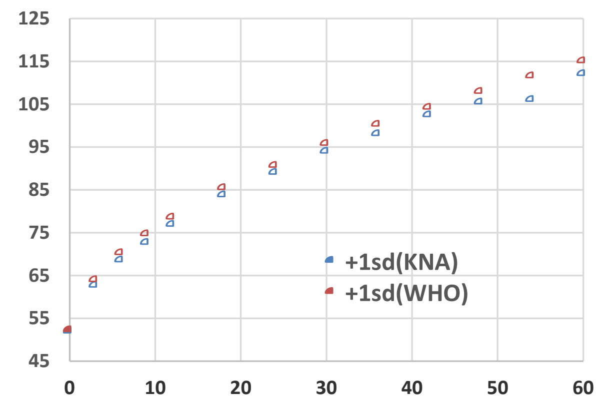
The study recommended that country standards may be more ideal for assessing growth than the WHO growth standards. However, in USA birth to 2 year WHO growth standards are used as the data are collected on breast fed children, for > 2 to 20 years CDC growth charts developed on American population are used.

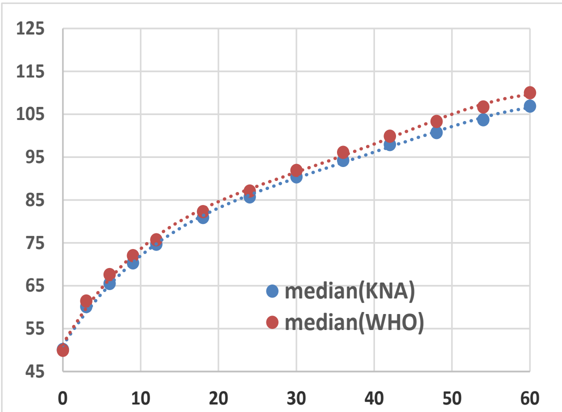
To compare the Z-score between WHO data and Agarwal growth data, z-score charts have been prepared. We have not plotted all the z-score values in a single chart as it makes it cumbersome and clumsy. Rather, we have plotted individual charts for all seven sets of z-scores i.e. -3sd, -2sd, -1sd, median, +1sd, +2sd, +3sd.

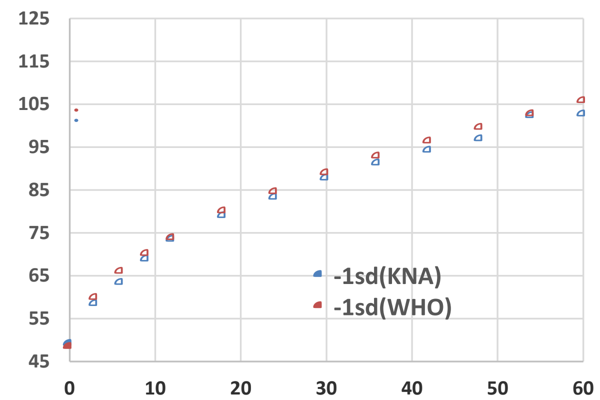
Height for age (Boys)

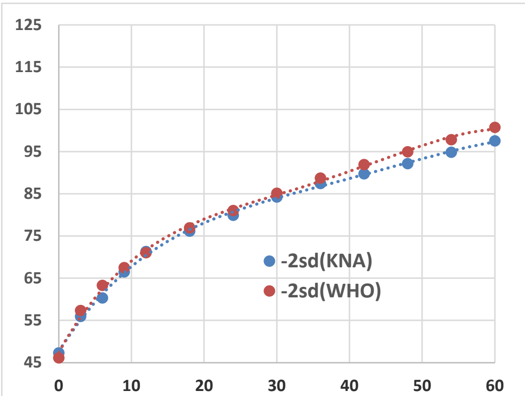


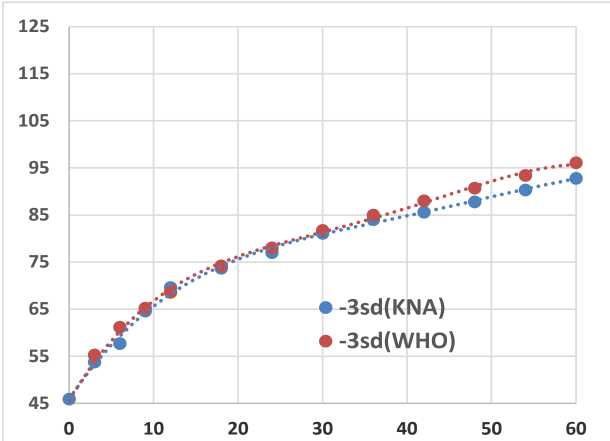












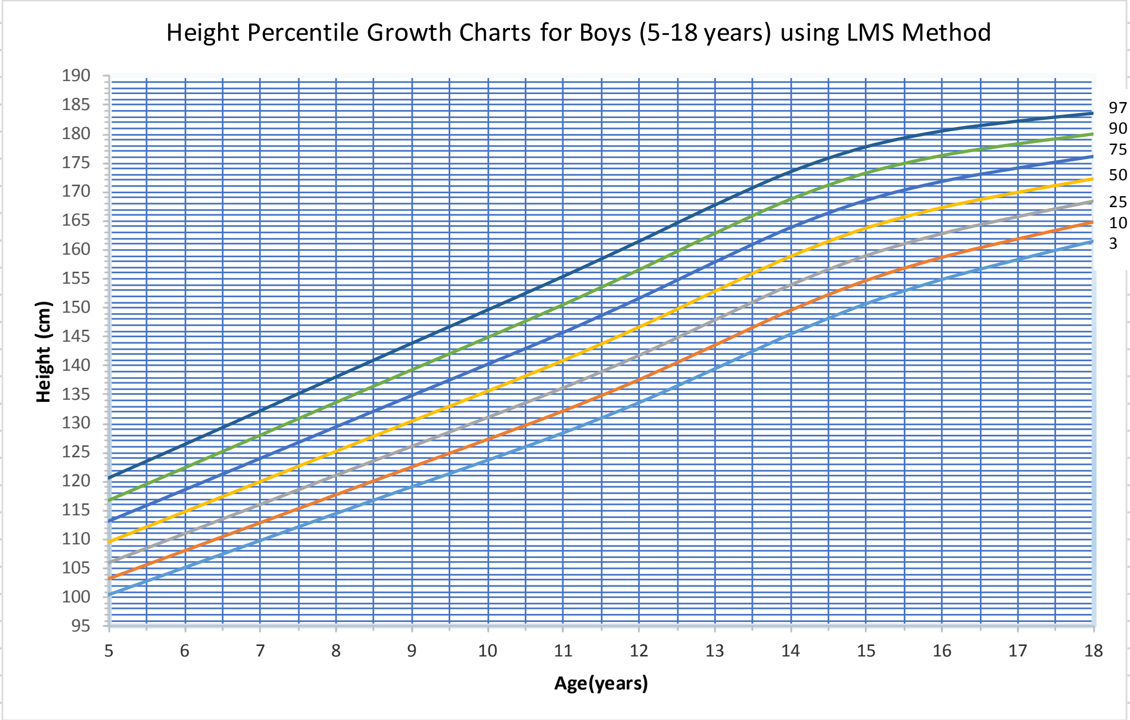
From these figures, it is evident that the shape or pattern followed is almost same for both the data. In the later age say from 3 to 5 years, the difference in z-scores is more as compared to, in initial age i.e. from 0 to 3 years. For +3sd scores, it ranges from 1.3 to 2.9 and overlaps between 0-6 months, for -3sd scores, from 1.5 to 3.3 and overlaps from 6 to 24 months. And, for median scores, it ranges from 1.3 to 3.1 and overlaps between 0-3 months. In the initial age, i.e. from 0-3 years, the shape follows the similar pattern and distribution of the attained height.

Five to 18 years of age-The Indian Council of Medical Research (ICMR) cross sectional data for physical growth and sexual development for 5 to 17 years in girls and from 5 to 18 years in boys (9 states- 23 schools; 12893 boys and 10,941 girls)[2] are the national data sets on affluent Indian children. These data on physical growth birth to 18 years of age will continue to serve as the baseline **reference** data for assessing growth, seeing secular trend in height, and % of children becoming overweight and obese in India. These graphs (Growth charts) have percentiles for height, weight, skull circumference and BMI for age and sex. After 10 years in girls and 12 years in boys growth parameters i.e. height, weight and BMI be assessed in relation to sexual maturity rating. A boy at 14 years may have different height values for SMR 2, 3, 4, 5 i.e. 150, 157,162,165 cm, respectively, mean value being 158 cm. The measurements and sexual grading was done by the same team at all centers using the same equipments.

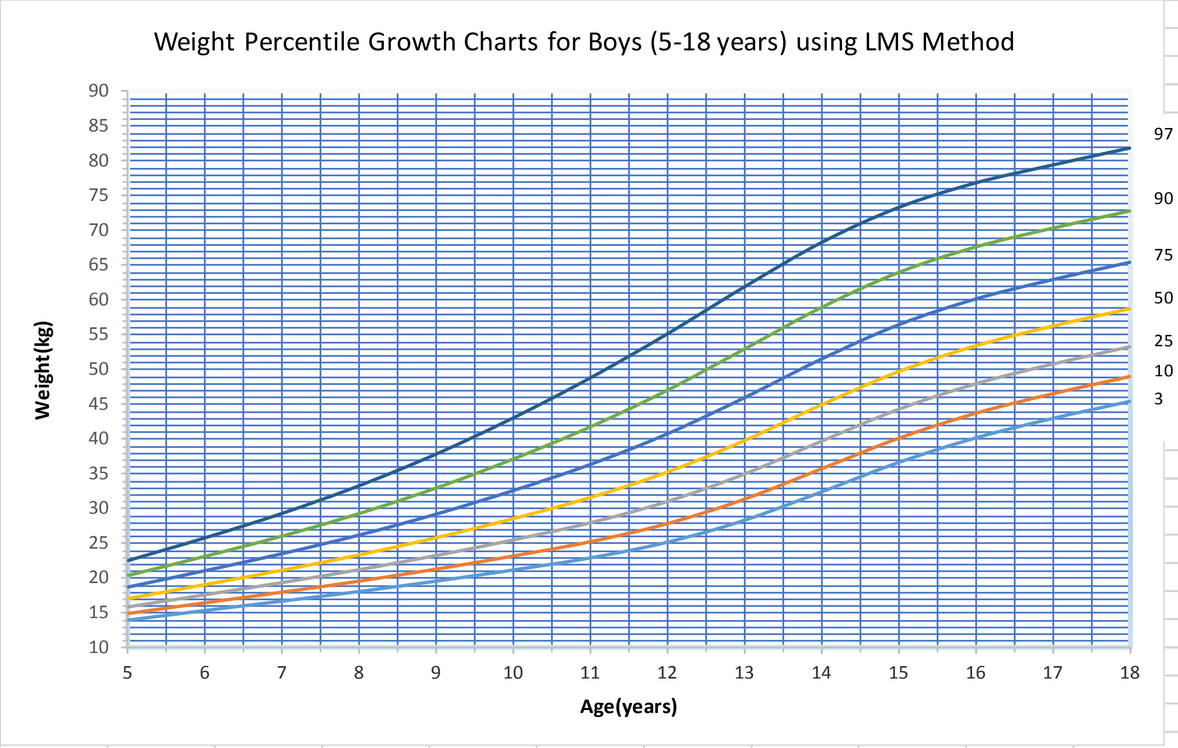
The growth curves given below were obtained by LMS method[10] which is used to construct smoothed percentile charts corrected for skewness. For healthy children, these charts are used as reference charts for evaluating the Physical Growth. Smooth curves, referred to as the Skewness L(t), Median M(t) and Coefficient of Variance S(t) curves were generated by plotting Lambda(L), Mu(M) and Sigma(S) values against 't' i.e. age categories. Through this method, the corresponding SD score for a particular subject is given by

$$\text{SD Score} = \frac{\left(Y/M(t)\right)^{L(t)}}{L(t).S(t)}$$

where Y is the measurement of a child at age t. This fitted model was tested for goodness of fit using Q-test and detrended Q-Q plots.



Agarwal et al, Indian Pediatr 1992



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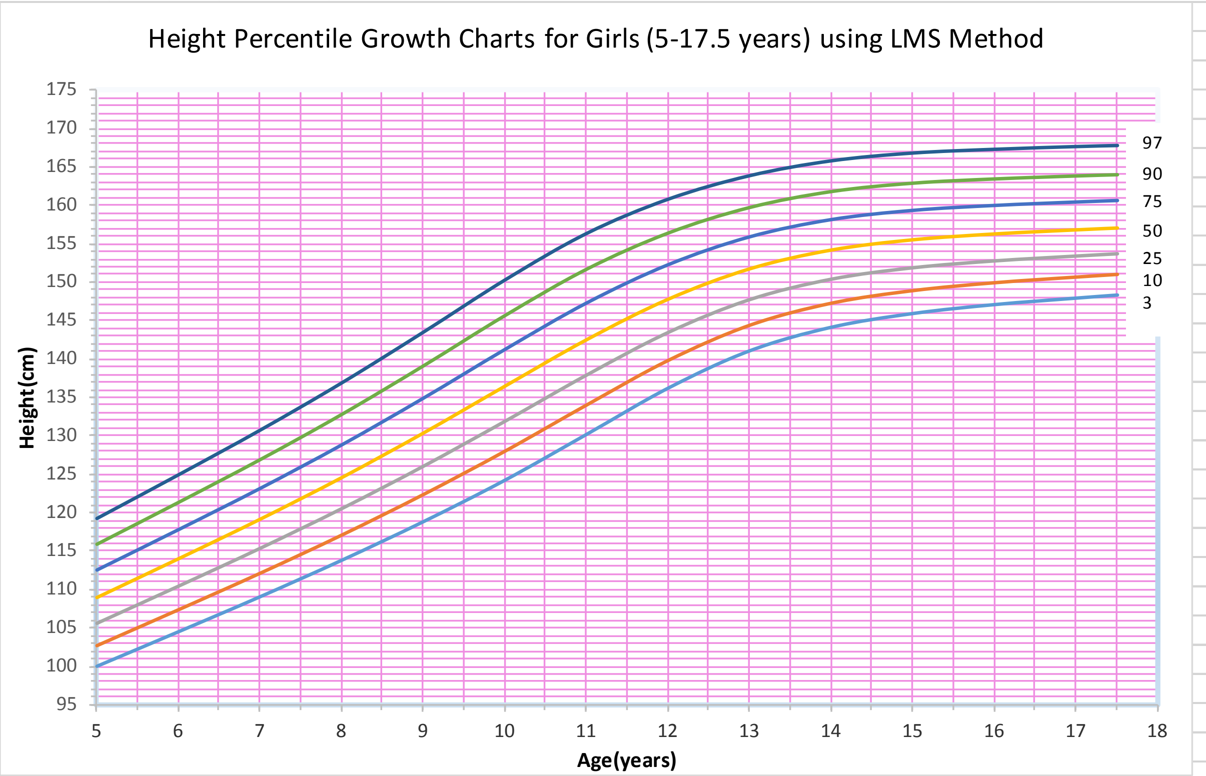

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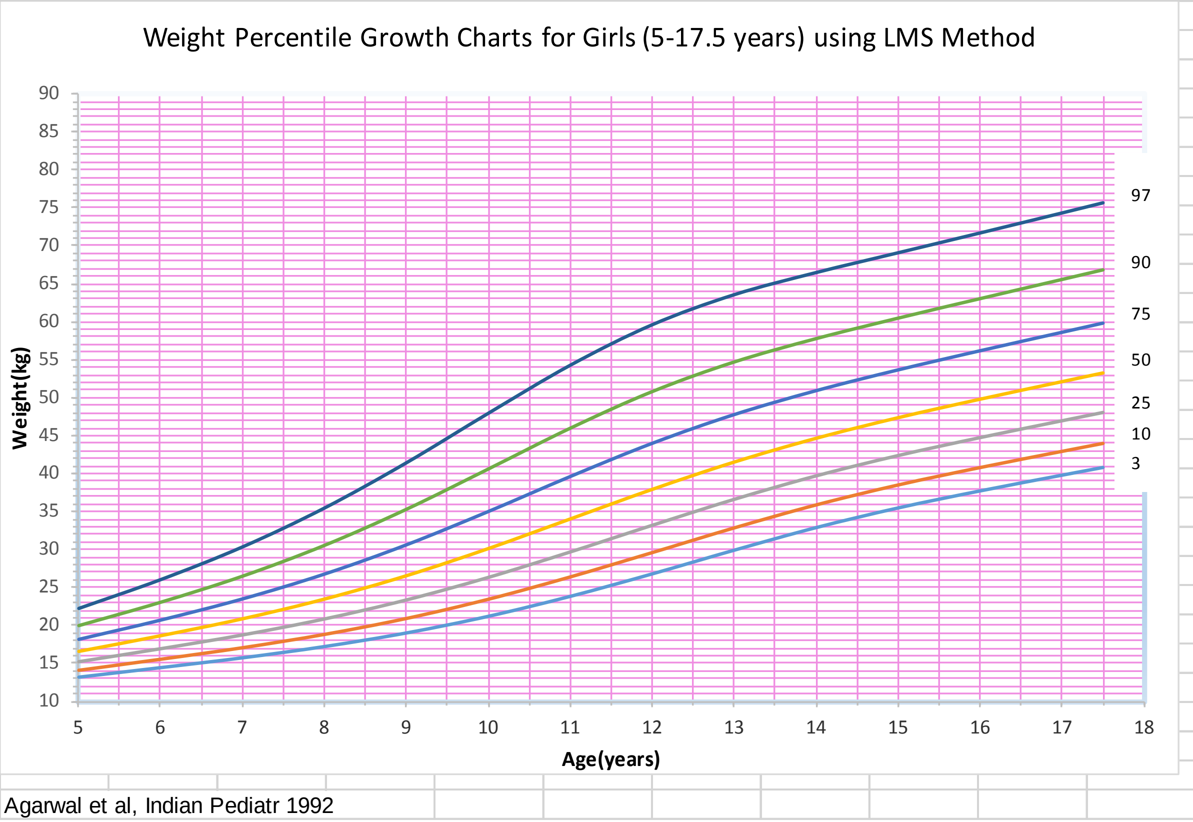
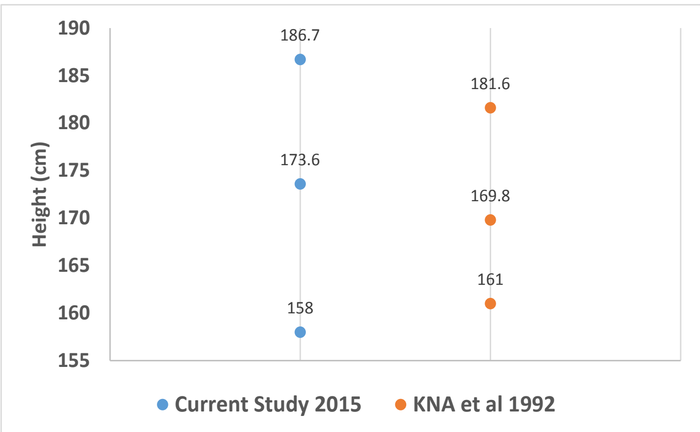
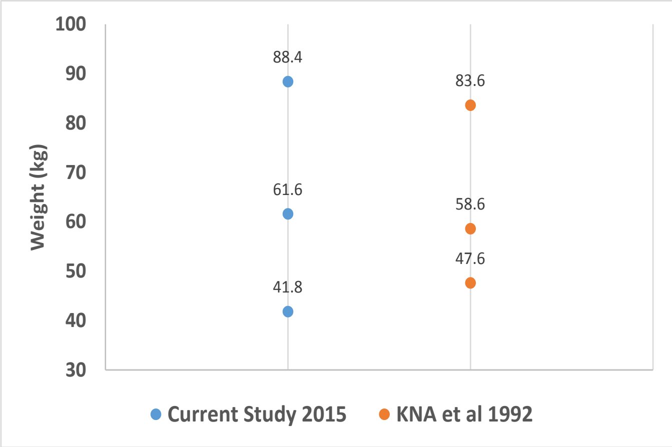


5. Boys Height and weight comparison at 18 years with Agarwal et al 1992[2] & Khadilkar et al 2015[10] data- Height differences (boys)

If we study the differences between the 3rd and 97th percentile values, the data in current study Khadilkar et al 2015[11] are more scattered as compared to Agarwal et al 1992[2], which is suggestive of more skewness on the left side of median value. In current study the difference is abrupt between the 3rd and 50th percentile but in Agarwal et al 1992[2], it seems consistent. Although, the secular trends are seen in height and weight for age after comparing these two studies, but this difference may reflect a secular trend towards overweight and under nutrition. *Thus 2015 IAP growth chart constructed on studies published by different authors remain unsuitable to detect early overweight and obesity and at the same time over estimate under nutrition.*





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