INTRODUCTION
The growth charts consist of a series of percentile/standard deviation or both curves that illustrate the distribution of selected body measurements in children. They are used in the assessment and monitoring of individual children and in screening whole populations.

COMMON INTERNATIONALLY USED GROWTH CHARTS AND THEIR DIFFERENCES
Pediatric growth charts have been used by pediatricians to track the growth of infants, children, and adolescents in the United States since 1977.

The 1977 growth charts were developed based on children from the USA, by the National Center for Health Statistics (NCHS). These were adopted by the World Health Organization as well and are called the 1977 NCHS growth charts or NCHS/WHO growth charts.

The 2000 CDC growth charts are the revised version of the 1977 NCHS growth charts. The main differences between the revised charts and the original charts were in the charts for infants, where national data were previously lacking. The revised head circumference charts also showed some noticeable differences when compared to the earlier charts. The original infant charts were based on primarily formula fed infants while the revised growth charts for infants contained a mixture of both breast and formula fed infants from the USA population. There was also addition of the body mass index (BMI) charts from 2 to 20 years.

Breast fed babies have a normal pattern of weight gain that slows down after the third month, and have a completely different growth pattern as compared to bottle fed babies who grow more quickly during the first four years. For term infants, rapid early growth increases the risk of obesity and cardiovascular diseases and is associated with earlier onset of puberty. Considering these facts the WHO Multicentre Growth Reference Study (MGRS) was conducted on the growth of healthy breastfed infants living in good hygienic conditions from 1997 to 2003 in 6 countries (Brazil, Ghana, India, Norway, Oman and the United States). The study combined a longitudinal follow up of 882 infants from birth to 24 months with a cross sectional component of 6669 children aged...
18-71 months. The study populations lived in socioeconomic conditions favorable to growth. The individual inclusion criteria for the longitudinal component were: no known health or environmental constraints to growth, mothers willing to follow MGRS feeding recommendations (i.e., exclusive or predominant breastfeeding for at least 4 months, introduction of complementary foods by 6 months of age and continued breastfeeding to at least 12 months of age), no maternal smoking before and after delivery, single term birth and absence of significant morbidity. Term low birth weight infants were not excluded. The eligibility criteria for the cross sectional component were the same as those for the longitudinal component with the exception of infant feeding practices. A minimum of 3 months of any breastfeeding was required for participants in the study's cross sectional component. Percentile and z score curves for various measurements were generated for boys and girls aged 0-60 months. These are called as 2006 WHO growth standards. These standards include data for weight for age, length/height for age, weight for length/height, BMI for age, mid upper arm circumference for age, triceps and subscapular skin folds for age, head circumference for age and the standards for increments for length, weight and head circumference. The full set of tables and charts is available at: http://www.who.int/child-growth/standards/en/. The charts for weight for age, length/height for age, weight for length/height and BMI for age are published in this article (charts 1-12).

The 2006 WHO child growth standards are truly international standards that show the fact that child populations grow similarly across the world when their health and care needs are met. The 2006 WHO growth charts are unique in that these are purposely designed to produce a standard unlike NCHS/WHO or 2000 CDC charts which are references. Strictly speaking, a reference simply serves as an anchor for comparison, whereas a standard allows both comparisons and permits value judgments about the adequacy of growth. Up till now at least 140 countries including the industrialized countries like USA, Canada, UK and Denmark have decided to use the WHO standards and are at different levels of implementation. The WHO standards also provide a better tool for monitoring the rapid and changing rate of growth in early infancy. There are notable differences with other growth references i.e. NCHS/WHO and 2000 CDC reference. These differences are particularly important in infancy. These include:

* BMI for age is not available as a part of the NCHS/WHO reference.
* There is also difference in the methodologies applied to construct the NCHS/WHO reference. There is significant skewing of the NCHS/WHO sample's weight for age and weight for height and separate standard deviations were calculated for distributions below and above the median for each of the two indicators. The WHO growth charts as well as CDC growth charts, on the other hand, employed >LMS (least mean squares) based methods that fit skewed data adequately and generated fitted curves that followed closely the empirical data.

* The spread of values for height and weight for height is narrower in the 2006 dataset (as compared to NCHS/WHO growth charts).
* The 2006 WHO growth standards generally reflect a lighter, longer/taller sample as compared to CDC and NCHS/WHO growth charts. When these are applied to the same population, the WHO Child Growth Standards will result in lower rates of underweight, wasting or thinness (except during the first six months of life), and higher rates of stunting, overweight and obesity.

The 2006 WHO growth standards are for children 0-60 months of age. For children of ages 5-19 years WHO developed 2007 growth references. The 2007 WHO growth references were made by the reconstruction of the 1977 NCHS/WHO references. These used the original 1977 NCHS data set (a non obese sample with expected heights) supplemented with data from the WHO
child growth standards sample for under fives. To
develop this reference the same statistical
methodology was used as in the construction of
the WHO standards\textsuperscript{6}. WHO chose 1977
NCHS/WHO rather than 2000 CDC charts as the
data was before the epidemic of obesity and
excluded unhealthy weights (>97th percentile).
The growth reference for older children (2007
WHO growth reference) focuses on linear growth
and BMI; weight for age data are age limited (5 10
years) and weight for height is omitted. The 2007
WHO growth reference charts and tables are
available at http://www.who.int/growthref/en/. The
charts for BMI for age (5 19 years), height for age (5
19 years) and weight for age (5 10 years) are
published in this article (charts 13-18). Adoption
of the WHO standards will harmonize assessment of
child growth within and among countries. Since
the prevalence of child obesity is higher according
to the WHO standards as compared to the CDC
reference, the WHO charts allow for a more timely
detection of obesity in childhood\textsuperscript{7,8}.

PLOTTING OF WHO GROWTH CHARTS

There are a number of curved centile lines printed
on the growth charts. The line labeled 0 (50th
percentile) on each chart represents the median,
which is, generally speaking, the average. The
other curved lines are z score or standard deviation scores (SDS) lines. Z score lines on the
growth charts are numbered positively (1, 2, 3) or
negatively (-1, -2, -3). The equivalency of Z score to
percentiles is shown in Table I.

<table>
<thead>
<tr>
<th>Z-score</th>
<th>Exact percentile</th>
<th>Rounded percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50\textsuperscript{th}</td>
<td>50\textsuperscript{th}</td>
</tr>
<tr>
<td>-1</td>
<td>15.9</td>
<td>15\textsuperscript{th}</td>
</tr>
<tr>
<td>-2</td>
<td>2.3</td>
<td>3\textsuperscript{rd}</td>
</tr>
<tr>
<td>-3</td>
<td>0.1</td>
<td>1\textsuperscript{st}</td>
</tr>
<tr>
<td>+1</td>
<td>84.1</td>
<td>85\textsuperscript{th}</td>
</tr>
<tr>
<td>+2</td>
<td>97.7</td>
<td>97\textsuperscript{th}</td>
</tr>
<tr>
<td>+3</td>
<td>99.9</td>
<td>99\textsuperscript{th}</td>
</tr>
</tbody>
</table>

Table I. Equivalency of Z-score to percentiles

The following four growth indicators should be
assessed in each child:

1. Length/height for age: This indicator helps
   in identification of children who are
   stunted.

2. Weight for age: This indicator is used to
   assess whether a child is underweight or
   severely underweight, but cannot be used
to classify a child as overweight or obese. If
a child has edema of both feet, plot this
child=s weight for age and weight for
length/height, but mark clearly on the
growth charts (close to the plotted point)
that the child has edema. This will show
that this child is severely undernourished.

3. Weight for length/height: This indicator is
   especially useful in situations where
children=s ages are not known (e.g.
refugee situations). Weight for
length/height charts help to identify
children that have low weight for height
called wasting). These charts also help to
identify children with high weight for
length/height who may be at risk of
becoming overweight or obese.

4. BMI for age: BMI for age (weight in
kilogram divided by height/length in
meter\textsuperscript{2}) is an indicator that is especially
useful for screening for overweight and
obesity. The BMI for age chart and weight
for length/height chart tend to show very
similar results.

The length is measured in children up to 24
months of age (or 87 cm if age unknown); height is
measured from 24 months onwards (or 87 cm and
higher if age unknown). The recommended length
height conversion factor is ± 0.7 cm (e.g. height =
length 0.7 cm) that is why at 24 month junction
graph may show discontinuous lines means
length lines higher than height lines e.g.
length/height for age charts\textsuperscript{3}. The interpretations
of all the four growth charts are shown in Table II.

The following points must be kept in mind while
using these growth charts:

1. Use the growth record for the correct sex
   since boys and girls grow at different rates
and sizes.

2. Then select the four charts (as mentioned above) to use.

3. Age is plotted in completed weeks from birth until age 3 months; in completed months from 3 to 12 months; and then in completed years and months.

4. Plot length or height on a vertical line. It will be necessary to round the measurement to the nearest whole centimeter (i.e. round down 0.1 to 0.4 and round up 0.5 to 0.9)

5. Plot weight on a horizontal line or in the space between lines to show weight measurement to 0.1 kg, e.g. 7.8 kg.

6. When points are plotted for two or more visits, connect adjacent points with a straight line to observe trends¹⁰.

GROWTH ASSESSMENT IN SPECIAL SITUATIONS

Since the WHO growth standards did not include data on premature infants/very low birth weight infants (<1500 g)/children in need of special health care (e.g. Down syndrome), modification may be necessary as done by the UK National Health Service² and the Canadian Pediatric Society¹¹. The recommendations from these developed countries include:

1. Children with intellectual, developmental, genetic or other disorders having growth patterns that are different from healthy children may also be monitored on either the WHO growth charts alone, or in conjunction with specific growth curves that exist for some of these disorders²¹¹.

2. If a newborn is healthy at delivery, but is born any time after 32 weeks, growth can be plotted on either the standard or the low birth weight chart. However, preterm infants who require hospital care will have data plotted on the preterm charts². The growth of preterm infants (<37 weeks) after discharge from the neonatal intensive care unit can be monitored using the WHO Child Growth Standards. Measurements should be plotted using corrected postnatal age for prematurity (i.e. postnatal age in weeks B [40 weeks B gestational age in weeks]) until 24 or 36 months of age e.g. at 12 weeks postnatal age, an infant born at 30 weeks gestational age would be 12   [+40 -30] or 2 weeks corrected postnatal age¹¹.

<table>
<thead>
<tr>
<th>Growth status</th>
<th>Z-score</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt; -2</td>
<td>Weight-for-age</td>
</tr>
<tr>
<td>Severe underweight</td>
<td>&lt; -3</td>
<td>Length-for-age from birth to 2 years</td>
</tr>
<tr>
<td>Stunting</td>
<td>&lt; -2</td>
<td>Height-for-age above 2 years of age</td>
</tr>
<tr>
<td>Severe stunting</td>
<td>&lt; -3</td>
<td></td>
</tr>
<tr>
<td>Wasting</td>
<td>&lt; -2</td>
<td></td>
</tr>
<tr>
<td>Severe wasting</td>
<td>&lt; -3</td>
<td></td>
</tr>
<tr>
<td>Risk of overweight</td>
<td>&gt; +1 from birth to 5 years; not applicable for older than above ages</td>
<td>Weight-for-length from birth to 2 years. BMI-for-age above 2 years of age</td>
</tr>
<tr>
<td>Overweight</td>
<td>&gt; +2 from birth to 5 years; &gt; +1 for older than above ages</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>&gt; +3 from birth to 5 years; &gt; +2 for older than above ages</td>
<td></td>
</tr>
<tr>
<td>Severe obesity</td>
<td>Not applicable from birth to 5 years; &gt; +3 for older than above ages</td>
<td></td>
</tr>
</tbody>
</table>

Table-I. The interpretation of all the four growth charts
IDENTIFICATION OF GROWTH PROBLEMS USING WHO GROWTH CHARTS

It is important to consider all children’s growth charts together, particularly if one of the charts is showing a problem. Initial values may be labeled on weight for age and length/height for age charts but follow up should be done either on the weight for age and length/height for age charts or on the weight for length/height chart. To identify trends in a child’s growth, look at points for growth indicators plotted at a series of visits. “Normally” growing children will grow in a “track” that is, on or between 2 and 2 z score lines and roughly parallel to the median; the track may be below or above the median. When interpreting growth charts, any of the following trends may indicate a problem or suggest risk:

1. If a child’s growth line crosses a z score line and the growth line tends towards the median, this is probably a good change. If it tends away from the median, this likely signals a problem or risk of a problem.

2. A sharp decline in the child’s growth line may indicate a problem except if a child has been ill and has lost weight. Similarly a sharp incline in the growth line may indicate a problem except if child is severely undernourished, a rapid gain (shown by a sharp incline on the graph) in the presence of gaining height can be good and indicate “catch up growth”.

3. The flat (stagnant) child’s growth line means there is no gain in weight or length/height. It may indicate a problem except in an overweight or obese child who is not gaining weight or even losing weight. In the presence of normal growth, an increase in height is a healthy change but if a child experiences no growth in height over time, there is a problem (flat growth line on the height for age chart). For children in age groups where the growth rate is fast, as shown by steep growth curves (e.g. during the first 6 months of life), even one month’s stagnation in growth represents a possible problem.

It is very important to consider the child’s whole situation when interpreting trends on growth charts. Whether or not the above situations actually represent a problem or risk depends on where the change in the growth trend began and where it is headed and the child’s health history.

BMI does not normally increase with age as do weight and height individually. BMI for age is similar to weight for length/height, and is useful for screening for overweight and obesity. It is important to note that overweight and obesity can co exist with stunting.

WHO GROWTH STANDARDS IN CONTEXT OF DEVELOPED COUNTRIES

Developed countries have modified growth charts in the light of the 2006 WHO growth standards. The UK WHO growth chart was launched in 2009 and was constructed using the WHO standards for infants aged 2 weeks to 4 years while the existing UK90 growth charts (based on combined cross sectional and longitudinal data that included a mix of breastfed and non breastfed UK infants) to be used for children over 4 years. Moreover there are no percentile lines between 0 and 2 weeks as some degree of weight loss is common in the first week and is regained by 2 weeks of age. These charts are available at: http://www.rcpch.ac.uk/growth charts.

There is a recommendation of the 2006 WHO growth standards for the assessment of growth among all children aged <24 months while for older children the use of 2000 CDC growth charts is recommended in USA.

The Canadian health societies recommend the use of the 2006 WHO child growth standards from birth to five years, and 2007 WHO child growth reference between the ages of five and 19 years.

FUTURE RESEARCH

Future research in other countries is needed as WHO growth standards may not apply in many countries. Moreover, such studies are needed.
to observe growth trends as there appears to have been an increase of about 1 kg in the weight of 1 year olds since the development of the first growth charts for postnatal health surveillance a century ago. This secular change can be observed for both breast fed and formula fed babies. There are no WHO growth standards for years 5–19, so these need to be developed as well.

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REFERENCES
Graph 1-12. 2006 WHO growth standards


8. Maalouf Manasseh Z, Metallinos Katsaras E, Dewey KG. Obesity in preschool children is more prevalent and identified at a younger age when WHO growth charts are used compared with CDC charts. J Nutr 2011; 141(6):1154 58.


