Growth charts from controversy to consensus

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ABSTRACT

Growth follows a specific set of patterns inspite of variability in children. This led to the development of growth charts. As growth provides an interplay of many factors, growth chart helps monitor growth and diagnose disease. They are also used for epidemiological purpose. There are many growth charts available. Training of health care workers to use and interpret growth chart in the children is needed for national health.

Key words: Growth chart, interpretation, WHO

INTRODUCTION

As under-five mortality speaks of health of a nation, a growth record speaks of health and disease in an individual child. Although there is a wide variability in the pattern of growth amongst children, it is interesting to observe that they follow a set pattern of growth, which is reflected in their anthropometric measurements. These observations led to the development of growth charts to assess growth of children. Growth is the result of interplay of many factors including fetal programming, physiological processes in childhood, and environmental factors. Thus, growth references are the most commonly used and most valuable tools for assessing the general well being of individuals, groups of children, and communities in which they live, and for tracking progress in reaching a range of health and other broader goals to social equity.

Regular monitoring of child’s growth gives reassurance to parents and physicians and also reduces the cost of unnecessary investigations. It is a proven method to suspect and diagnose disease early before major damage is done, and at the same time, it is useful to monitor response to treatment in a diseased child.[1]

What are growth charts?

Growth charts are percentile curves prepared from population-based studies where anthropometric measures are collected from a large number of children in a cross-sectional manner. Sophisticated statistical methods are then applied to generate percentile values and standard deviations. Percentile values are smoothened to produce growth charts, also known as growth reference curves. Smoothening methods such as cubic spline or LMS are used to design growth charts. Cole’s LMS method[2] is one of the most popular one used to create growth curves.

Types of growth charts in use

Commonly used growth charts are height, weight, BMI, and head circumference. Many other charts such as sitting height, subischeal length, biacromial diameter, knee height, skin fold thickness etc. are available but are mainly used for research purpose. Most growth charts have standard 7 percentile lines viz. 3rd, 10th, 25th, 50th, 75th, 90th, and 97th. BMI charts have 85th and 95th percentile to define overweight and obesity cut offs. WHO BMI charts[3] for under-five children have +1 and +2 sd lines to define overweight and obesity, respectively.

Height Charts

Height charts are used from birth to 18 years of age in both sexes. They are very useful to monitor the length/height of
the baby and child over a period of time. These charts are also known as distance charts. In the first two years, length is measured and after which height is used for monitoring purpose. Age is divided into monthly intervals. In some places (United Kingdom), decimal age is used to divide each year into 10 equal parts. When using these charts, decimal age calculation is necessary. Along with distance charts, height velocity charts are used to monitor growth velocity. These charts are particularly useful to pick-up growth failure early, as growth velocity is a more sensitive indicator of growth failure.

**Weight charts**
These charts are used from birth to 18 years in both sexes. In infancy, weight monitoring is more often used than in later childhood (1-3 monthly in infancy vs. 6 monthly in childhood). In India, growth monitoring of children older than 5 years remains an area of concern, and the Indian Academy of Pediatrics has urged pediatricians to use growth charts until the age of 18 years (at 6 monthly intervals). Weight charts are useful to diagnose both failure-to-thrive as well as obesity.

**BMI charts**
Body mass index (BMI) is a measure of fatness. BMI charts are useful in diagnosing overweight and obesity at all ages. In children, there are no single cut off values for overweight and obesity as in adults, and hence these charts are necessary. In addition to the usual standard 7 percentile lines, BMI charts have two other lines viz. 85th and 95th to diagnose overweight and obesity, respectively.\(^4\) International Obesity Task Force\(^8\) (IOTF) and WHO have defined their own adult equivalent BMI cut offs to define obesity and overweight. Recently, the author and colleagues have\(^6\) defined 23 and 28 adult equivalent cut offs to define overweight and obesity for Indian children from the age of 5 to 18 years. These cut offs were used instead of 25 and 30 adult equivalent because WHO has recommended lower BMI cut offs for Asian Indians due to their higher fat content at a given BMI.

**Head circumference charts**
Head circumference charts are mainly used from birth to 5 years of age.

**Difference between standard and reference**
Standard is prescriptive while reference is descriptive. Thus, standard is what is optimal and desirable, whereas reference is what is prepared from the existing population, which is supposed to be living in the best possible environment. A typical example is weight reference curves prepared from affluent populations of today are not a standard. On the other hand, WHO MGRS 2006 charts\(^3\) are growth standards. These were prepared from a population of children where the environmental variables such as socioeconomic class, maternal smoking, breast-feeding etc. were controlled. Data from 6 countries viz. USA, Ghana, Brazil, India, Oman, and Norway was used. These WHO standards are thus prescriptive rather than descriptive. In other words, there was a shift in the focus from ‘how children grow in a particular region and time,’ i.e. reference charts to ‘how they children should grow when their environment and nutrition is controlled’ i.e. standard charts.

**How to interpret growth charts?**
Growth charts have 2 axes. X axis has age, and Y axis has the respective parameter such as height, weight, BMI etc. Anthropometric parameters are measured and plotted against the specific age on the X axis. Parameters are plotted as a small dot and not as circle or cross. If the plotted dot falls between the 3rd and 97th percentile lines, it is considered as normal. 50th percentile is considered as average. The danger lines change from chart to chart. In case of height chart, any reading above or below 3rd or 97th percentile is abnormal. In case of height velocity chart, anything below 25th percentile for age is considered abnormal. For interpretation of BMI, any child above the 85th percentile is overweight and above 95th percentile is obese. These cut offs are different for IOTF and WHO charts. Movement of more than 2 percentile lines on a growth chart over a period of time either upward or downward is considered significant.

Height charts need to be interpreted in the context of target height. Target height is calculated using the formula: (Mother’s HT + Father’s HT + 13)/2 for a boy and (Mother’s HT + Father’s HT - 13)/2 for a girl. This is then plotted on the graph at 18 years, and that point represents the 50th percentile for the family. Use of target height is useful to reduce unnecessary tests in familial short stature.

Some growth charts such as sitting height and subischial leg length are presented as standard deviation scores and not percentiles. If the discrepancy between leg length and sitting height is more than 2 sds, then it is considered significant.

**Available standards and references:**
As of 2012, following growth charts are available
1. WHO MGRS standards for children under the age of 5 years
2. NCHS (American) References for children from 0-19 years
3. Indian Academy of Pediatric growth charts – Growth monitoring guidelines 2007 for 0-18 years (Khadilkar et al. Derived from 1989-92 data by K.N. Agarwal et al.)
4. Khadilkar et al. 2007 Indian growth references for height, weight, and BMI for 2-18 years
5. IOTF BMI charts for 5-18 years old children
6. Khadilkar et al. 2012 – BMI cut offs for 23 and 28 adult equivalent BMI values for 5-18 year old Indian children.

**CONCLUSION**

To conclude, growth charts are the standard accepted way to monitor growth, diagnose disease, and monitor improvement. It is important that health care workers use growth charts from birth until maturity i.e. 18 years of age.

Most of the world has accepted WHO MGRS 2006 standards for monitoring growth of under-five children. Indian academy of pediatrics and Govt. of India have also accepted these standards for under-five growth monitoring. For monitoring growth of children above the age of 5 years, it is recommended that the most recent nationally representative references for height and weight should be used. For BMI, which is important in diagnosing obesity, either IOTF charts can be used or country-specific 23 and 28 adult equivalent cut offs such as those recently published by Khadilkar et al. can be used. Besides their use in the epidemiology, growth charts are immensely valuable to diagnose disease and monitor improvement in an individual child as well. Training of health care workers to use and interpret growth charts is a very necessary part of national health. When used properly, these are formidable tools in the hands of a health care provider.

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