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## REVIEW ARTICLE

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# *Monitoring growth*

Angélica M.B. Zeferino,<sup>1</sup> Antônio A. Barros Filho,<sup>2</sup> Heloisa Bettiol,<sup>3</sup> Marco A. Barbieri<sup>4</sup>

### Abstract

**Objective:** To present concepts related to growth assessment, with emphasis on aspects concerning the evaluation of individuals.

**Sources:** The present paper is based on reports published by the WHO regarding the use anthropometry for the assessment of nutritional status; on original articles; and on book chapters about the same topic, as well as on the criticisms of auxologists of this type of assessment when employed at the individual level.

**Summary of the findings:** Concepts concerning reference, skeletal maturity, mid-parental target height, z score, short stature, growth rate, body mass index, and their assumptions and limitations are presented.

**Conclusions:** The assessment of the nutritional status of a population is based on cut-off points, taking into consideration that whoever is below or above that point presents a nutritional problem. Clinical evaluation is based on the idea of variability, which can be both biological and social, and on the idea that it is the clinician's task to establish whether a child within or outside given parameters presents normal growth and nutritional status. When monitoring the growth of a child or adolescent, the most important parameter to be considered is growth rate.

*J Pediatr (Rio J) 2003;79 Suppl 1:S23-S32:* Growth, anthropometry, growth curve, maturation, nutritional status, short stature, obesity.

### Introduction

Growth monitoring is an important tool to get information about health, either individually or collectively. Villermé, in 1828, had already acknowledged the influence of the environment on growth. This author perceived that social

conditions not only interfered with the final height of Napoleon's soldiers, as far as their origin was concerned (whether they were from poorer or well-off families), but also found out that these social conditions had an impact on their rate of growth, known today as maturation. This observation was not readily accepted and, during the 19th century, authors from different countries discussed whether growth was genetically inherited, resulted from social conditions or was influenced by geographical position.<sup>1</sup> Currently, it is widely accepted that growth is related to genetical inheritance (passed on by parents, not by the ethnic group), but strongly influenced by the environment,

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1. PhD, Assistant Professor, Department of Pediatrics, School of Medicine, Universidade Estadual de Campinas.  
2. Professor of Pediatrics, Universidade Estadual de Campinas School of Medical Sciences.  
3. PhD, Assistant Professor, Department of Child Care and Pediatrics, School of Medicine, Ribeirão Preto, Universidade de São Paulo.  
4. Professor, Department of Child Care and Pediatrics, School of Medicine, Ribeirão Preto, Universidade de São Paulo.

both physical (climate, altitude) and social (especially diseases and nutrition.) Based on the important influence that living conditions have over growth, international entities, such as the World Health Organization (WHO) and national entities such as the Ministry of Health and the Brazilian Society of Pediatrics (SBP) recommend growth monitoring as routine practice in well-child care.<sup>2-5</sup> However, this monitoring, albeit recommended for over 30 years, is still controversial among health care providers, especially in terms of individual surveillance. This controversy occurs because the literature presents two approaches simultaneously without taking into consideration that they have distinct logics and presuppositions: the nutritional assessment of populations and the nutritional assessment of an individual, that is, in the epidemiological and clinical viewpoint, respectively. These two points of view have sparked off debates and encouraged publications that are not always within the pediatrician's reach, but which reflect erroneous concepts applied to daily practice. The aim of this article is to show aspects of these two concepts, with emphasis on their application.

### Methodology

The present article is based on the texts that greatly influenced the current concepts of growth monitoring, especially those resulting from expert meetings summoned by WHO and by those authors who disagree with these proposals<sup>6-8</sup> and recommend other forms of nutritional assessment. The proposal made by Morley,<sup>9,10</sup> who gave rise to the current nutritional assessment of children under five, is also discussed. The different aspects will be presented in topics, with highlight on their peculiarities, and combined at the end, showing the differences between one type of assessment and the other.

### Classification of nutritional status

Gómez, in 1946,<sup>11</sup> proposed a classification that is internationally known today. At that time, he was a pediatrician in charge of a nursery full of undernourished children. He decided to investigate the prognosis and recovery time of his patients and described them by using an objective criterion that was not solely based on clinical parameters. For that, he adopted the 50th percentile of Stuart & Meredith's curve, which was the most popular at that time. This proposal spread so fast that basically all countries carried out nutritional assessment by using Gomez classification during the 1960s and 1970s. With the application of this classification in varied contexts, some problems began to arise, among which three are noteworthy: in several regions where malnutrition was highly prevalent, it was not possible to obtain children's ages; as the assessment was based on weight, many children were actually light for their age because they were short; and the decision on which curve to use (which will be discussed in the next section).

Therefore, criteria that were not age-related were proposed. Arm circumference is relatively unrelated to age between the sixth month and fourth year of life, but does not inform about the chronicity of malnutrition, and is therefore used in emergency situations. The weight/height ratio, which was initially thought of as independent of age, proved wrong. In the early 70s, a new proposal for nutritional assessment was drawn up.<sup>12,13</sup> This new proposal was more complex than Gomez classification. It included weight for height for the diagnosis of acute malnutrition, and height for age for chronic (or previous) malnutrition. WHO recommends the use of the descriptive (rather than diagnostic) terms wasted and stunted.<sup>4</sup> The problem with age was not solved, but two processes of malnutrition were created: a recent one (wasted, or wasting if it is ongoing) and a chronic one (stunted, or stunting if it is ongoing.) With regard to stunted or stunting, we should clarify that the process that causes it occurs in the first three years of life,<sup>14</sup> in such a way that, if a group of children is assessed for up to three years, we may say malnutrition is chronic, and only after this age it is possible to say it refers to a previously pathological family history.

Thus, there are three indices - weight for age, weight for height, and height for age - for nutritional assessment with the aim of detecting malnutrition. However, an issue still has to be dealt with: which cutoff point should be adopted?

Research also pointed out that the rate of deviation from the median, as proposed by Gómez, did not take into account the variability of weight and height measurements in terms of age

WHO sponsored a meeting<sup>15</sup> in which criteria for nutritional assessment, which are in effect up to now, were established. The weight for height and height for age should be used as indices and cutoff points instead of the rate of deviation from the median, and so should statistical concepts such as percentile and standard deviations (or z score).

After observing an increase in the prevalence of obesity, especially in the United States and in Europe, in the early 1980s, another anthropometric index, the body mass index (BMI) was adopted. The BMI is calculated using the weight (kg) divided by the squared height (m).<sup>16</sup> As this index is age-dependent in children and adolescents, specific curves should be used.

### Standard or reference

A common error in growth monitoring consists in using growth curves as if they were standards. Although several authors drew some attention to this, the error still persists. Every standard is a reference, but not every reference is a standard. Standard is something everyone should measure up to, while reference is used to make comparisons. In Brazil, the expression "reference standard," aside from being linguistically redundant, reinforces the idea that the National Center for Health Statistics-NCHS (1977)<sup>17</sup> should be

regarded as a standard. This way, it should be underscored that for any curve, either for the nutritional diagnosis of populations or for assessment of individual growth, nobody will use a standard that equals that of the adopted curve.

### Growth curves

Both the assessments of nutritional status and growth involve comparison with a reference curve. Even a mother, when she brings her child in for a medical appointment, states her complaint by using a comparison: the child is the shortest in his/her class, is shorter than his/her cousins, a younger sister is growing faster than the son. Health care providers make comparisons by using reference curves.

There are two ways for constructing reference curves: the cross-sectional and the longitudinal ones. A third method, known as mixed longitudinal study, is used with cross-sectional and longitudinal data, but it is more complex. Each method presents advantages and disadvantages. The cross-sectional method is more widely used because it is cheaper and quicker. The curves are elaborated using measurements taken only once from a certain population of

a country, region or city, and based on these measurements, the distribution of average values and of dispersion is determined. This is the way in which the NCHS 17 curves and those of Marques *et al* are built<sup>18,19</sup> (Table 1). In the longitudinal method, the data are obtained from the same group of people, from birth to adulthood. This method allows building curves for growth rate, and the assessment of growth rate is the best parameter to detect whether a child is growing up properly. However, this method demands an extended follow-up. Therefore, this type of curve is more appropriate to assess growth at the clinic. So far, there exists only one growth curve that contemplates this principle - the curve developed by Tanner *et al*.<sup>21,22</sup> (Table 1).

To establish values according to age, two statistical procedures are used: mean and standard deviation, or median and percentiles. Height has a Gaussian distribution (normal), which indicates that the mean and median may have similar values, and that both sides of the distribution, above and below the mean, also present similarities. The distribution of weight, weight for height and of BMI is not of Gaussian type. This characteristic yields different mean and median values. The use of standard deviation causes distortions to the extreme thresholds of the assessment, in which the -2SD

**Table 1** - Characteristics of growth curves according to the method employed

| Curve name   | Year   | Method                                    | Population studied   | Data  |
|--|--|---|--|---|
| <b>NCHS</b><br>( <i>NCHS Growth Curves for Children Birth-18Years United States, Nov.1977</i> )                            | I- Data collected from <i>FELS Research Institute</i> - children from 0 to 3 years                                     | I- Longitudinal                           | I- Middle class, healthy and Caucasian children  | Weight/Age<br>Height/Age<br>Weight/Height                             |
|  | II- Data collected from NCHS ( <i>National Center for Health Statistics</i> ) - children from 3 to 18 years            | II- Cross-sectional                       | II- Sample from all American children, including non-white children and of low socioeconomic status  |   |
| <b>Marques &amp; Marcondes</b><br>( <i>Pediatria Básica, Eduardo Marcondes, 8th ed., 1999</i> )                            | 1968-1969: children from 0 to 12 years (1,533 children)<br>1978-1979: adolescents from 10 to 20 years (3,082 children) | Cross-sectional study                     | Boys and girls from 3 to 239 months from socioeconomic status IV (high) from Santo André   | 5th, 25th, 50th, 90th and 95th percentiles for Weight and Height      |
| <b>Tanner, Whitehouse, Takahishi curve</b><br>( <i>Archives of Diseases in Childhood 1966; 41: 454-71 and 41: 613-35</i> ) | I- From birth to 5 years<br>Published in 1966  | Mixed longitudinal                        | I- Children from central London  | 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles<br>Growth rate |
|  | II- Five to fifteen years (1,000 boys and 1,000 girls from each age) - (Scott, 1961)                                   |   | II- Randomly chosen children and schools from London   |   |
| <b>Preece et al.</b><br>( <i>Archives of Diseases in Childhood 1995; 73: 17-24</i> )                                       | Data from seven sources, measured between 1978-1990  | LMS method of Cole for percentiles design | Populational data submitted to comparative tests - the authors considered that the sample used was significant to represent the whole British population | 3rd, 50th and 97th percentiles  |

falls below the 3rd percentile, which may underestimate low weight, and falls below the 97th percentile, also underestimating overweight. As it is recommended that the z score or standard deviation units be used to assess growth and nutritional status, there would be distortions in the assessment. To solve this problem, we calculated different standard deviations for the distribution of weight and weight for height below and above the mean in the calculation of the z score through the program developed by NCHS and found in the Epi-Info software program. This calculation is an adaptation, considering that, in fact, we have two normal distributions that overlap. Thus, for these two anthropometric indices, tables with different standard deviations were built.

Although useful and practical, this adaptation is not correct. Cole proposes a new form to elaborate these distributions, known as LMS, which takes into account this difference in distribution and corrects it by way of logarithmic transformation of real values, before elaborating the distribution. This was how the new curves for the Center for Diseases Control (CDC)<sup>23</sup> and for England<sup>24</sup> were created.

### Growth monitoring

In the early 1980s, with the proposition of basic health measures, the Ministry of Health implemented the "child card." In addition to information about return dates and vaccine schedules, the child card contained a growth curve for weight, from birth to the age of five years. This proposition was adapted from Morley<sup>9</sup> and Morley and Woodland.<sup>10</sup> Morley proposed that weight surveillance could inform whether a child showed nutritional disorders before malnutrition was clearly evident. Thus, the health agent could take preventive measures. This curve, called "health path," was developed according to some practical principles: it was designed for use by health agents where a paucity of physicians existed, where reading and writing was difficult and in regions where populations moved away frequently. Hence, the large intervals, with no gender-specific distribution; the card should be kept by the family, not by the health service. This proposition drew so much attention from health authorities in several countries to the importance of regular assessment of growth in children that WHO decided to implement it in their own proposition. Their version basically follows the same principles, the only difference is that it is stratified by gender. Since the curve is cross-sectional, it does not have a curve for growth rate. The curve for growth curve is inferred from the slope the child presents in his/her curve. If the curve follows the design, the child is developing well; if it is parallel to the x axis, the child is at risk; if the curve is descending, the child is in frank malnutrition. Note that the diagnosis is based on the curve slope and not on the point where it is at. This is a cross-sectional view, an assessment that presumes the follow-up of the child. Thus, a child may be below the lower reference limit, but when reassessed some days later, he/she may show growth. The diagnosis points to a small child, as

a sequela of a previous process or not. Another child, however, may be above the lower limit, but with the curve parallel to the x axis, which shows zero weight gain rate, indicating a warning sign. And a third child with values greater than the 50<sup>th</sup> percentile (for example), but with a descending slope, indicating weight loss, and moving towards malnutrition. We should bear in mind that, in this case, the diagnosis is not made from a cutoff point on the curve, but according to the child's growth. This is one of the mistakes made by Health Departments when they set cutoff points to provide resources for nutritional recovery. The card that the Ministry of Health supplies uses NCHS curves.<sup>17</sup> In the state of São Paulo the situation is peculiar, as cards are supplied by the Ministry of Health and growth graphs on public records are elaborated with data obtained from Marques *et al.*<sup>18</sup>

Another way to monitor growth is to assess height in different moments, as in the case of data from the National Program of Household Sampling (PNAD) in 1975 and from the National Survey into Health and Nutrition (PNSN) in 1989. These surveys show through different methods that the nutritional situation has improved in Brazil. Studies of secular trend are a way to check nutritional, health and social situations of a population.<sup>25</sup>

### Growth rate

We should bear in mind that the diagnosis of a growth disorder cannot be made in a single appointment. We may infer, however, that the patient has short stature or, in case of an infant, that he/she presents low weight. Short stature or low weight for age refers to a value below a certain cutoff point, which may be below the 3rd percentile, as is the case of Tanner curve, or below the 5th percentile, as in the NCHS curve, or even below the 10th percentile, as neonatologists use in Lubchenco curve. To be below a certain cutoff point does not necessarily mean that the patient has a growth disorder, and these cutoff points are arbitrary. The lower and upper limits of the reference curves are estimated according to the sample size at the time of their construction. With current statistical resources, it is possible to calculate more extreme percentiles, but at the time these curves were built, this was not possible. We should always remember that the 3rd percentile means that three percent of normal individuals are below that value. This way, many children who seek medical care due to short stature are indeed extreme variants of normality (around 80% of children with short stature). What indicates a growth disorder is the growth rate. Rate means space divided by time. In case of growth, it means the height gain within a certain time interval. Pediatricians deal with this definition every day, and perhaps they are not aware of it. When we say that an infant gains 30 g/day in the first quarter of life, we are applying the notion of rate. The same occurs with height. The child grows on average 25 cm in the first year, 15 cm in the first semester and 10 cm in the second one. In the

second year, however, the child grows only 10 cm, and after this age he/she grows between 5 and 7 cm a year until the beginning of puberty, when growth rate increases again and reaches an average peak of 9 cm/year for the girl and 10 cm/year for the boy. As height gain is low, short-term measures may be masked by measurement errors (when performed in too short periods). Therefore, we recommend that height measurements be performed with at least three months between each other. The calculation consists of decimal time; thus, three months are equivalent to one quarter of the year (0.25). If during this period a four-year-old grows 1.5 cm, by dividing this gain by 0.25, we have the rate of 6cm/year, which complies with the height expected for age. For a more accurate assessment, we should use Tanner and Whitehouse<sup>22</sup> graphs, which present growth curves from birth to adulthood. As the NCHS<sup>17</sup> and CDC<sup>22</sup> curves do not have growth rate curves, an alternative, as proposed by Cole<sup>25</sup> is to calculate the z score of the first and second measurement and then subtract the first from the second one. If the difference is greater than zero, the rate is increasing; if it is equal to zero, the rate is stable; if less than zero, it is decreasing. Remember that the rate is not always increasing. In the first two years of life it is decreasing, then it stabilizes, and in some cases, it decreases again near the growth spurt, and increases at the first stage of puberty and decreases at the second stage, until its rate is zero in adulthood. Growth rates below the 10<sup>th</sup> percentile are regarded as risk, since 80% of children below this value present some problem.

### Parental target height

Another important aspect in the clinical assessment of the patient with growth disorder is the determination of the parental target height.<sup>27</sup> This concept is quite relevant, as it relates child's height to that of his/her parents. The height of parents should be checked, since these data are usually incorrect if provided by the mother and father themselves. Parental target is established by adding 13 cm to the mother's height, in case of male patients, or by subtracting 13 cm from the father's height, in case of female patients. After this, the mean height between the parents is calculated and transcribed to the graph. For males, we should add 10 cm above and 10 cm below, thus determining the height interval which 95% of the children of this couple are expected to reach in adult life. For females, we add and subtract 9.0 cm, in order to establish this margin (Table 2). The value of 13 cm is proposed as it is the difference in mean height of adults between men and women.

### Maturation

Just as there are height differences at each age, there are also differences in growth rates. In other words, some children grow faster while others grow more slowly. And puberty is the time at which this aspect is clearly perceived.

Here, we should draw attention to two terms that are often used as synonyms, but which, although they are concomitant in a certain moment, are totally different: puberty and adolescence. *Puberty* is a biological phenomenon, characterized by physical and physiological changes that occur between the ages of nine and fifteen, including the development of secondary sexual characteristics and the establishment of the reproductive capacity. *Adolescence* is a biological, psychological and social phenomenon that, although it starts during puberty, may last longer, including maturation in terms of psychological and social behavior. Thus, a 16-year-old may be regarded as adolescent, but as an adult in physical terms. He/she has already grown as genetically expected and is sexually mature for biologically expressing his/her sexuality. As the definition of adolescence is not accurate in terms of beginning and end, it may cause confusion at times. In Brazil we have two definitions of adolescence, one by the Brazilian Child and Adolescent Statute, which defines adolescent as an individual between 12 and 18 years, and another one by the World Health Organization, which defines an adolescent as an individual between 10 and 20 years. Anyway, for the sake of growth assessment, we find it more appropriate to use the definition of puberty.

Initially the delayed onset of puberty caused some concern and when such delay did not result from health problems, it was called constitutional delay in growth and puberty. However, although this phenomenon is more evident at puberty, it may occur from the first moments of life (2-3 years). The clearest difference is observed between sexes, since girls are more mature than boys and their growth spurt occurs on average two years before, and as they reach adult characteristics two years before boys do. The fact that girls enter the growth spurt two years before, at a time in which growth rate is around 5.5 cm/year, plus a growth rate 2 cm/year greater during the growth spurt, theoretically explains the average difference of 13 cm between men and women, used for calculating the parental target.

The method growth specialists use to assess biological maturation, and verify whether a child has a faster or slower growth rate consists of the determination of bone age. There are several methods for evaluating bone age, but the most widely used are that of Greulich-Pyle<sup>28</sup> and the TW2.<sup>29</sup> Both methods assess the bone development of left hands and wrists. The Greulich-Pyle method is more widely known and consists of an atlas with x-rays of hands and wrists, with which professionals may compare their patients' hands and wrists. The TW2 method consists of a scoring system, in which 20 bones of the left hand and wrist are separately evaluated and assigned a letter that indicates the maturational stage. Each stage receives a score, and the sum of scores leads to a final figure. This figure is checked against a table, from which bone age is established. The TW2 also subdivides into other two methods: RUS (*Radio, Ulna*

**Table 2** - Formulas to calculate parental target height, growth rate, z score and body mass index

|  |  |  |
|--|--|--|
| <b>Parental target height</b> *                    | Girls:   | $\frac{\text{Mother's height} + (\text{father's height} - 13 \text{ cm}) \pm 9}{2}$                |
|  | Boys:  | $\frac{\text{Father's height} + (\text{mother's height} + 13 \text{ cm}) \pm 10}{2}$               |
| <b>Growth rate</b> †                               | GR (cm/year) = $\frac{\text{Current height} - \text{previous height}}{\Delta \text{ time gap between measurements (years)}}$ |  |
| Note: compare GR to the reference curve            |  |  |
| <b>z score (SDS)</b><br>(standard deviation score) | SDS = $\frac{(X - \bar{X})}{SD}$   | X= measured height<br>X̄= reference height<br>DP= reference height standard deviation for that age |
|  |  |  |
| <b>Body mass index</b>                             | BMI = $\frac{\text{Weight (kg)}}{\text{Height}^2 \text{ (m}^2\text{)}}$  |  |

\* More effective assessment from 2-3 years up to 9-10 years.

† Minimal time interval of 3 months, and maximum time interval of 12 months.

and *Short Bones*) and *Carpal* (which only assesses carpal bones), following the same principle of the TW2 methods, but with their own scores and specific tables.

The method that is most largely recommended by growth specialists is the TW2, which was developed so that the observer pays attention to each bone, performing a more careful evaluation; out of simplicity and widespread fame, the Greulich-Pyle method is the most widely used internationally. Anyway, each method provides information with some differences, as they were based on x-rays of the hand obtained at different times and from different populations. In Brazil many health services do not have any of these atlases, and radiologists give their opinion by comparing the x-rays with figures published in textbooks. In addition, both methods are based on x-rays of the left hand and wrist, and in order that the determination of bone age can be as reliable as possible, only the left hand and wrist should be x-rayed, instead of both hands and wrists, as often occurs, which increases the possibility of errors.

Obesity, hyperthyroidism and the use of sexual hormones accelerate bone age, but most diseases delay it. Chronic diseases (e.g.: heart and kidney diseases), malnutrition, GH deficiency, and hypothyroidism may delay bone age. In clinical activity, the number of standard deviations of bone age in relation to chronological age are determined by accepting two standard deviations above or below when, respectively, delayed or accelerated bone age are

considered.<sup>28,29</sup> However, if two children with the same chronological age and same height have different bone ages, for instance, one child one year older and the other one year younger, this means that the one with delayed bone age will enter puberty later and will be able to reach the highest adult age.

### Assessment of puberty

This task is arduous but rewarding. It is arduous because families that seek medical help are anxious about the delayed development of their child, and rewarding when the health professional is able to clear up doubts, explain the differences between individuals, say that the child's development is as expected and reassure the families that puberty will occur at the right moment. As previously mentioned, there are individuals who enter puberty at the age of nine, and sometimes before that, while others only do so at the age of 15 or 16, without implication of a disease. Thus, at the age of 14, it is possible to observe a boy still at the prepubertal stage, another one in the middle of puberty, and another one who has already reached adulthood. The same may occur with girls, at even an earlier age.

In general, puberty in girls starts with the development of the breast bud, followed by the height spurt. Menarche is an event that occurs at the end of puberty, when the growth rate is decreasing. After the menarche, girls still grow on

average 7.5 cm, with a variation between 3 and 17 cm.<sup>30</sup> Puberty in boys starts with the increase in testicle size. Puberty is said to start when testicular volume is at 4 cm<sup>3</sup>, and the pubertal spurt occurs when testicles reach from 8 to 10 cm<sup>3</sup>. Thus, if a boy presents any characteristic of pubertal development without concomitant increase in testicle size, we should suspect of a tumor, which could be causing such changes.

For assessment of the development of secondary sexual characteristics, we use the criteria established by Tanner<sup>31</sup> (Table 3).

**Table 3 -** Stages of male and female pubertal development

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**Development of pubic hair in males and females**

- Stage 1 -** Absence of pubic hair.
- Stage 2 -** Disperse distribution of pubic hair, small amount, slightly pigmented, straight or slightly curled, surrounding the basis of the penis or along the labia majora.
- Stage 3 -** Hair spreads on the pubic symphysis and is rather darker, coarser and usually more curled.
- Stage 4 -** Adult -type hair, but the area covered is less than that in most adults; there is no spread to the medial surface of thighs.
- Stage 5 -** Distribution is as an inverse triangle in women; adult -type hair regarding amount and appearance, with increased spread to medial surface of thighs.

**Genital organs**

- Stage 1 -** Infantile appearance from birth to the beginning of puberty. During this period, genitals do not increase much their overall size, but there is a slight change in their general appearance.
- Stage 2 -** Scrotum has enlarged, and there is a change in the texture of scrotal skin and some reddening of scrotal skin.
- Stage 3 -** Growth of the penis has occurred, at first mainly in length but with some increase in width. There has been further growth of the scrotum.
- Stage 4 -** The testes and the scrotum are further enlarged and the penis is further enlarged in length and width.
- Stage 5 -** Genitalia are adult in size and shape.

**Breasts**

- Stage 1 -** Infantile appearance, only papillae are elevated.
- Stage 2 -** Breast bud and papilla are elevated and a small mound is present; areola diameter is enlarged.
- Stage 3 -** Further enlargement of breast mound and areola, without defining outline.
- Stage 4 -** Areola and papilla are elevated to form a second mound above the level of the rest of the breast.
- Stage 5 -** Adult mature breast; recession of areola to the mound of breast tissue, rounding of the breast mound, and projection of only the papilla are evident.

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From *Clinical Nutrition Assessment of Infants and Children*, chap. 54, p. 886.

**Assessment of growth and classification of short stature**

Several diseases that affect growth are accompanied by other physical changes, often observable on clinical examination (Down's syndrome and Turner's syndrome, mucopolysaccharidosis, bone dysplasia, etc). The problem occurs when the patient does not show other signs and the only finding is short stature. The most frequent causes of short stature in children are extreme variations of normality; in these cases, growth rate is normal. In Brazil, another frequent cause of short stature is chronic malnutrition, which appears prenatally or postnatally. Past history may provide information about weight and length at birth and/or about eating habits and living and housing conditions of the child's family. Physical examination may reveal suggestive signs of some disease that might be hindering growth. Chronic diseases usually interfere with growth, affecting stature and delaying bone age. In this case, height in adulthood might not be affected, but delay in reaching the targeted height occurs.

The height of the patient and of both parents should be obtained, and the parental target should be calculated, so that we can have an idea about the growth channel. As previously mentioned, growing is a dynamic process, so we may not say whether a child is not growing properly in one single assessment. If the child is below the 3rd percentile, he/she has short stature. In general, the diagnosis of growth disorders is not urgent and the patient can be seen within three months, for calculating growth rate, which is the most important parameter for establishing the diagnosis of inappropriate growth. In the new medical appointment, bone age should be assessed.

Various propositions have been made by several authors for the classification of short stature<sup>32-39</sup> and so far there is no common agreement about an ideal classification. Some criteria have been used, such as: etiology, pathogenesis, absence or not of congenital or acquired proportion of body segments. Most classifications use the etiological criterion, with special emphasis on pathologies. The justification for this is the early diagnosis of treatable growth disorders.

With regard to short stature without pathological causes, the most common groups are:

***Familial short stature (genetic)***

Children below the 3rd percentile with normal growth rate, whose growth history complies with that of the family. Parents (one or both) are short and a variable part of the family members will be below the 3rd percentile, and therefore these children may become short adults. No delay in bone age occurs and puberty and pubertal spurt occur at the usual chronological age.

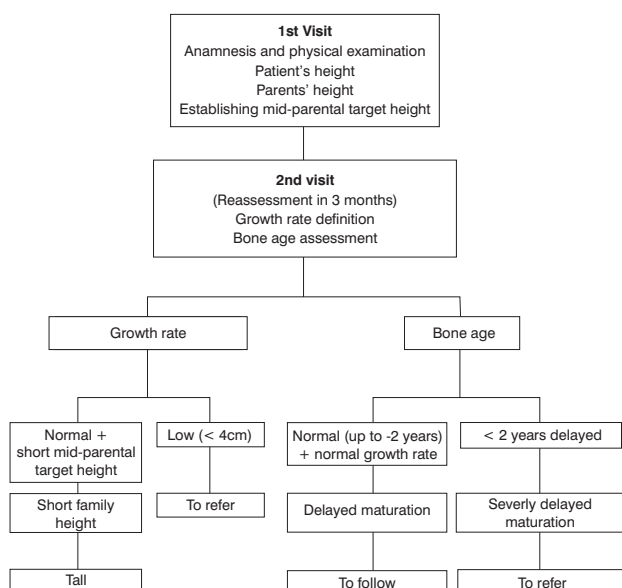
### Constitutional short stature

Also known as constitutional delay in growth and maturation. These children have normal size at birth, show delayed growth in the first or second year of life and remain below the 3rd percentile, with normal growth rate throughout childhood. They present relevant delay in bone age and the onset of puberty, development of secondary sexual characteristics and growth spurt are also delayed. Parents are not short and the family's growth channel is above the 3rd percentile, with normal potential for final height. Usually, there is family history of pubertal delay.

Several authors suggest combining both groups<sup>32-34,37-41</sup> (constitutional short stature/familial growth delay), when children are below the 3rd percentile of Tanner & Whitehouse<sup>22</sup> curve, showing delayed bone age in relation to the chronological age and being within the family's growth channel. However, there are few references about the combination of family components for short stature and delayed growth and maturation, as a separate group,<sup>36,41</sup> and there is no information about pubertal events and final height in this group.

Other diagnoses of normal short stature variants are not present in all classifications. In addition to malnutrition, some authors include low birthweight<sup>32,34,36-38,41</sup> and uncertain or idiopathic causes.<sup>32,36,37,39</sup>

Figure 1 shows a decision algorithm in relation to the diagnosis of short stature.



**Figure 1** - Assessment of short stature

### Assessment of obesity

From the 1980s onwards, another problem was starting to expand - obesity. At the beginning, it held the attention of industrialized countries, but over time, several studies showed that it was a problem in developing countries as well, not only in richer but also in poorer countries. Differently from malnutrition, which can be eliminated by allowing access to food, obesity is of special concern, not only because of the harms it causes on health but also because of its complex treatment and control, since it requires changes in eating behavior and adoption of public policies that might go against the interests of different sectors of society.

Just like malnutrition, obesity is also part of the history of humankind. However, malnutrition was always associated with poverty, while obese individuals were considered to be rich and healthy, or even as a beauty standard at certain times and in certain societies. The idea that being fat is to be healthy is still acceptable for chubby children or someone who has just recovered from a serious illness. After the recognition of a series of diseases associated with obesity, in the 1950s, forms to prevent it were researched, but given its spread in the last 30 years, we see that such initiatives did not yield satisfactory results.<sup>42</sup>

Growth monitoring is an important tool for the early identification of obesity.<sup>43</sup> Although it accelerates maturation and consequently height gain, weight gain is always more pronounced. The physician may observe that weight gain is not in line with height gain and should alert the family. This is always a delicate situation in the first year of life. First because this is usually the period in which fat tissue develops, and secondly because a chubby infant is considered healthy. Eating history may help the physician to distinguish between gaining weight as an individual characteristic and gaining it due to overeating. However, after the second year of life the child loses weight. If the child is relatively heavier than taller, it might be a sign that he/she is becoming obese. It should be underscored that when obesity is detected in children, these do not know the implications that overweight may have on their health and life. At this time, parents should make them aware of that. If any of these children is obese, nutritional counseling will not be successful, except if the physician convinces the family about the risks of overeating. Under this circumstance, one should not forget the role of grandmothers in helping or advising mothers about their child's diet.

The body mass index (BMI) (Table 2) has been recommended for the diagnosis of obesity. For the diagnosis of obesity among adults, the WHO recommends the following cutoff points: from 20 to 25 kg/m<sup>2</sup> eutrophy; from 25 to 30 kg/m<sup>2</sup>, overweight; and from 30 kg/m<sup>2</sup> over, obesity.<sup>16</sup> Although internationally recommended, this indicator receives some criticisms, especially because it does not distinguish between overweight and fat muscle or bone mass. In spite of this, epidemiological studies have shown good relationship with fat mass, besides the fact that



it is a widely known and easily applicable indicator. To assess the nutritional status of children and adolescents, in addition to the criticisms mentioned above, the BMI has some problems since it relies on height, which in its turn varies according to age. This way, there are two suggestions for the use of this indicator, with their respective indices: one by Must *et al.* (1991),<sup>44</sup> and another by Cole *et al.* (2000).<sup>45</sup>

In the first suggestion,<sup>44</sup> with NCHS data, assessments are based on the distribution of BMI from six years old to adulthood, considering the 85th percentile as cutoff point for the diagnosis of overweight, and the 95th percentile as cutoff point for obesity. The second suggestion<sup>45</sup> is more complex, since it involves a series of assumptions. The first of them is that the growth curve on which the cutoff points are based for the diagnosis, is a curve that contains data from six countries (Brazil, United States, United Kingdom, Holland, Singapore, and Hong Kong). Another assumption is that it is an adaptation of the indices proposed by the World Health Organization (25 for overweight and 30 for obesity). Once the curve is built, the percentiles corresponding to these values at the age of 18 are determined. This proposal has been internationally accepted, but has recently received some harsh criticism,<sup>46</sup> which will probably cast some doubt on it. In the opinion of the authors of this article, in addition to the criticisms presented in Reilly's article,<sup>46</sup> there is another one: what is a curve that contains data from different countries? It is nothing but an exercise, since it does not represent anybody; not even the countries that provided the data for construction of the curve. It is safer to compare the data from similar populations, and then adapt them according to the local conditions than to use a curve whose ethnical or regional peculiarities are lost in a cluster with no identity. Therefore, we recommend using the proposal of Must *et al.*,<sup>44</sup> which is based on clearly defined statistical concepts, with the remark that each country should build its own BMI curve, as the United States is one of the countries in which obesity is extremely frequent.

## Conclusion

The assessment of growth has become increasingly important for monitoring health and nutritional conditions of individuals and populations. To assess the conditions of populations, we can use the previously described anthropometric indicators or the average height according to age in different moments or places. For individual assessment, antropometry is an ancillary tool, since it has to be assessed in a context where clinical and social history of the patient, physical examination, parental data, growth rate and bone age can be compared.

Assessments of an individual's life in different moments may contribute to explaining what occurred in previous phases and thus indicate immediate and late health risks. Therefore, the assessment of size at birth may help

professionals to take immediate decisions on the health care of newborns and during the first years of life.<sup>47-50</sup> Health risks at other ages may also be evaluated, such as final height and problems like cardiovascular disease, diabetes, arterial hypertension, hypercholesterolemia, and obesity.<sup>51-53</sup>

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Corresponding author:

Antonio de Azevedo Barros Filho

Departamento de Pediatria/FCM/UNICAMP

Caixa Postal 6111 – CEP 13084-973 – Campinas, SP, Brazil

Tel./Fax: +55 (19) 3788.7193/3788.7322

E-mail: abarros@fcm.unicamp.br