

ANTHROPOLOGY AND HEALTH

Pavel BLÁHA, Jana VIGNEROVÁ

Abstract: *Surveys conducted in children and adults clearly show secular trends in their body parameters with typical positive, i.e. upward, trends. The parameter which is most frequently monitored and at the same time, is most indicative of general changes is body height. Progressive increase in mean body height can be seen in many countries not only in adults but also in children and adolescents of all age groups. Changes in body height are associated with variation in other parameters such as body weight with characteristic positive trend. Nevertheless, body weight has recently been increasing more rapidly compared to body height which leads to higher prevalence of overweight population.*

Keywords: *health, secular changes, children, adolescents, basic body characteristics*

1 Introduction

Secular changes, both positive and negative, result from interaction between a person's genetic background and environmental factors. Differences in living conditions between social groups and progressive changes in these conditions in a long term run are to be taken into account in this regard. The child's nutrition status, health, psycho-social and socio-economic conditions are among the major factors influencing body height.

Changes in body height of children and adolescents are associated with variation in developmental dynamics, particularly in the teenage population. In general, the developmental phases are accelerated as can be best documented by progressive shift of the early pubescent growth spurt and sexual maturation toward younger age groups.

Surveys of the basic body characteristics in children and adolescents are the simplest tools for assessment of health and nutritional status in both individuals and population groups. Early detection of any deviation from the expected trend in body characteristics may be indicative of serious disease, poor nutritional habits, mental disorders or other problems in children.

To be able to assess whether or not a child's body characteristics are proportionate to age we need to compare these characteristics with reference data available for a given population, most often in form of growth (centile) charts.

Growth charts for basic body parameters are an effective tool in every day paediatric practice. They are also used in clinical practice, mainly in the treatment of obesity, endocrinology, surgery, etc. Nevertheless, these charts are not to be used as a single tool but should always be considered in context of other relevant factors.

1.1 Basic Body Characteristics

Two basic anthropometric characteristics are used as the major body growth indicators: body length (in children under two years of age) or height and weight. Other supplementary characteristics are head, waist, hip, arm and thigh circumferences and selected indices. Head circumference is assessed in children less than 3 years of age. The most frequently used index is the Body Mass Index (BMI), i.e. the ratio of weight in kilograms to the square height in metres. Each characteristic is always considered separately with reference to gender and age. A chart based on the body weight to height ratio is also used for pre-teen aged children with body weight related directly to height rather than to age.

Centile Charts

In many countries worldwide, the growth charts are based on data from large national studies to describe children's growth in a given area and for a given period of time. In 1977 the World Health Organization (WHO) in Geneva together with the National Centre for Health Statistics (NCHS), USA, recommended the reference growth charts of body height, weight and weight for height constructed for children under 3 years of age based on a longitudinal study of the North American population and for older children based on three transversal studies of the North American population. Table 1 summarizes the reference data used in the world, indicating the numbers and percentages of countries using each type of reference data.

Table 1 *Worldwide practices in child growth monitoring (reference population)*

Reference data	Countries	
	Number	%
NCHS/WHO	99	68
Tanner	3	2
Harvard	13	9
Local	25	17
Other	17	12
Unknown	6	4

The calculation of centiles for body parameters in each age group provides so called empirical centiles, i.e. values that were actually obtained by measurements in a given set of subjects. The centile for a given age means that the indicated percentage of children of the study set reach the given or lower value. (e.g. the 97th centile for body height of 9 - 10 years old boys is 151 cm. It means that 97 % of Czech boys are as tall as 151 cm or shorter while 3% of boys aged 9 - 10 years are taller than 151 cm). The population group studied has to be representative of the given population so as the obtained centiles could be considered as valid for the entire selected population group.

By plotting the empirical centiles for each age group we obtain a centile chart for the given parameter. To smooth the centile lines various mathematical methods are used. Advances in computing technology and resulting availability of more sophisticated software led to the development of other more accurate methods. Currently the LMS method is used most frequently in constructing centile charts.

In centile charts, represented lines usually correspond to the 3, 10, 25, 50, 75, 90 and 97 centiles for reference data at a given age. The 50th centile, i.e. the bold line in the middle of each growth chart, usually represents the most frequent value for the body parameter found in the reference population. The more distant other lines are from this middle line, the more extreme values they represent. Values above the middle line are higher than the average for the population of a given age while those below the middle line are lower than the average.

With the widespread epidemic of overweight and obesity in all age categories, and not only in industrialized countries, BMI is used worldwide in children as well. While the limits for underweight, normal weight, overweight and obesity in adults are set regardless of age, those for children are clearly age dependent (see Figures 1a, 1b). Therefore, a changed BMI value in a child cannot be interpreted as reflecting either body weight reduction or increase without knowledge of the reference data. Similarly, whether a child is underweight, overweight or obese can only be considered in comparison with the reference data.

Assessment of body parameters with reference to body height rather than to age is often replaced by that with reference to height age, i.e. age for which the measured body height corresponds to the 50th centile. At this point, age is read, being higher than calendar age in above average tall children and lower in below average short children (see Figure 2).

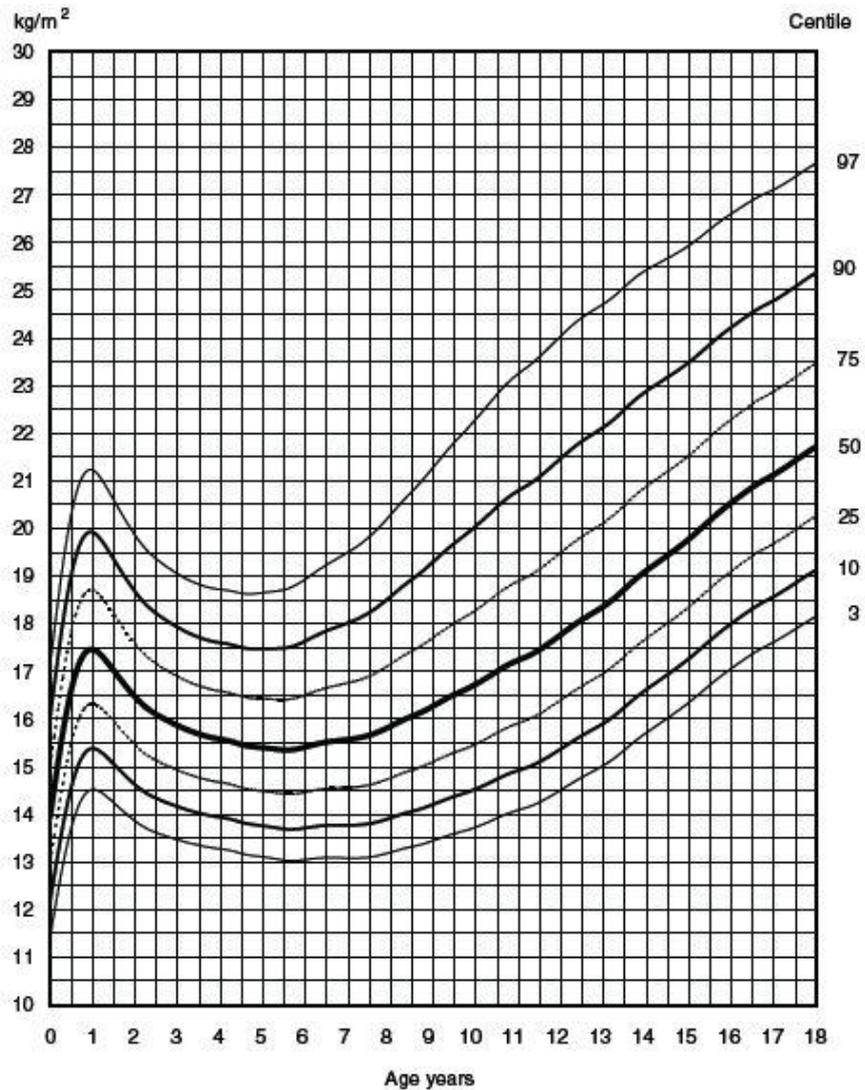


Figure 1a – Czech reference BMI growth chart, boys, 0–18 years.

A weight for height chart is an example of assessment of body build related to body height. This chart is indicative of a child's body build regardless of age, only in relation to body height, (Figures 3a, 3b).

Growth Charts for Breastfed Children

In practice, the reference data recommended by NCHS/WHO appeared unsuitable for growth assessment in breastfed children. One of the greatest limitations to their usability is the fact that these reference data are based on a predominantly bottle fed infant population. It was reliably proved that bottle fed children considerably differ in growth from breastfed children.

Inconsistency between the existing charts and recommendation of breast milk as the optimal nutrition source for infants was the reason for creating growth standards for breastfed children.

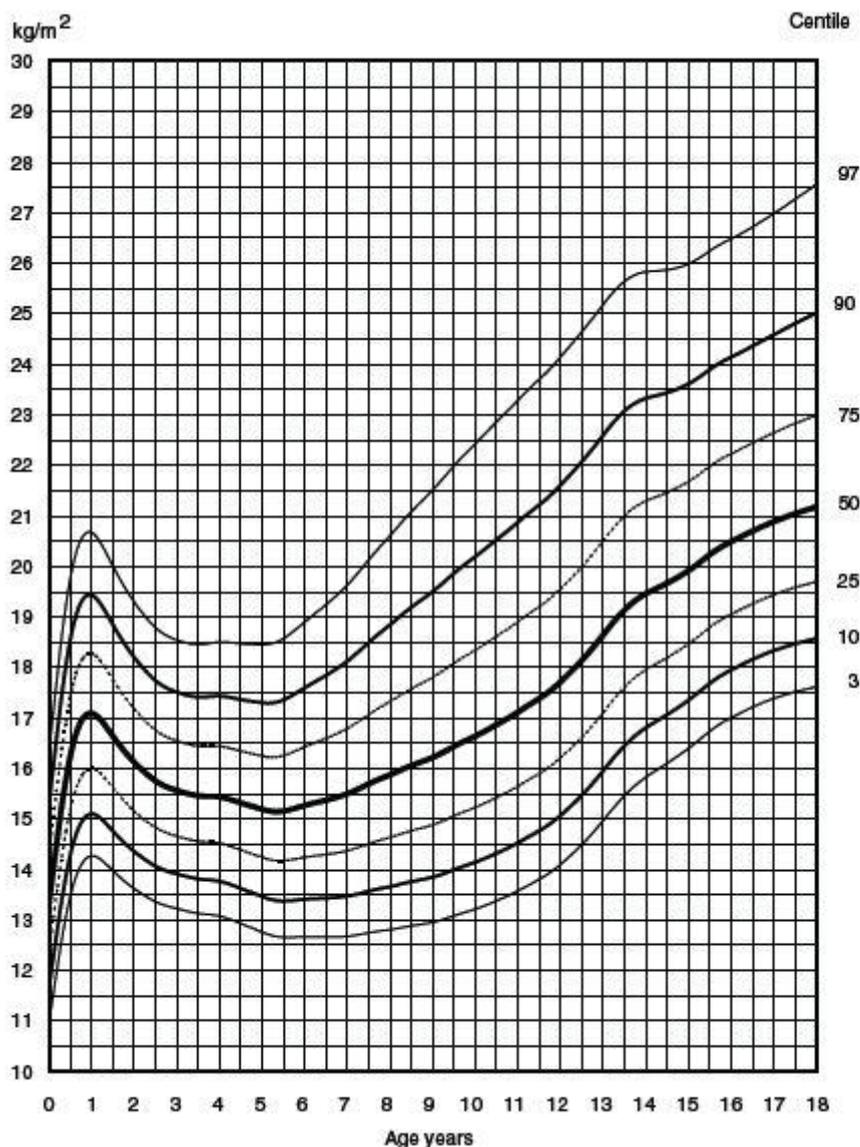


Figure 1b – Czech reference BMI growth chart, girls, 0–18 years.

In 1994, WHO decided to create new international growth standards to be based on a sample of healthy breastfed children from different countries. The WHO Multicentre Growth Reference Study (MGRS) conducted between 1997 and 2003 was designed to collect data on growth and development of 8440 children from different ethnic and culture groups. The starting assumption was that under favourable socio-economic conditions, with mother's non-smoker status and adherence to MGRS feeding recommendations, children up to 5 years of age show the same growth and development regardless of ethnic origin.

MGRS combines a longitudinal study of children up to 24 months of age with a cross-sectional study of children aged 18 to 71 months. Criteria for the selection of the subpopulations, from which the children for the study were chosen, were favourable socio-

economic conditions for growth, low mobility, with at least 20% of mothers willing to follow the feeding recommendations, and having access to breastfeeding support (e.g. the Baby-Friendly Hospital Initiative (BFHI) and breastfeeding support groups).

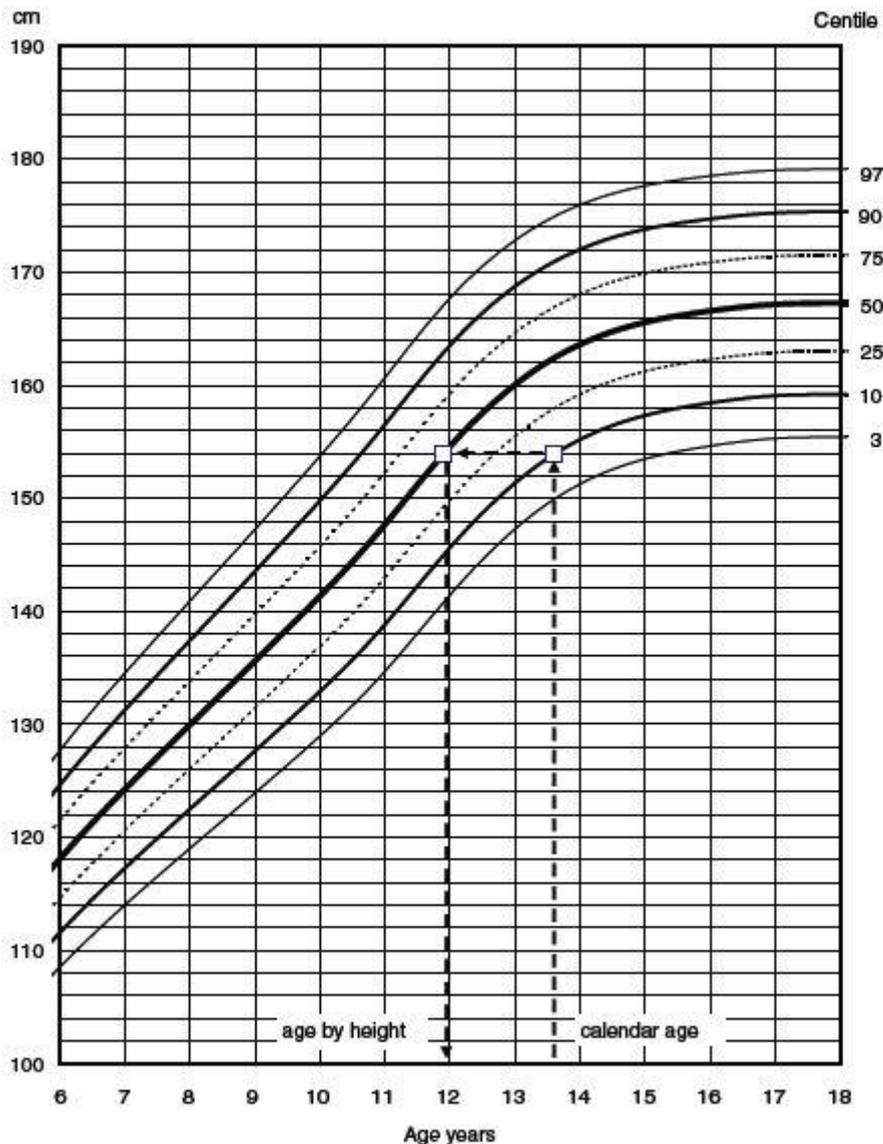


Figure 2 – Czech reference height growth chart. Calculation of height age.

Criteria for the selection of children for the study were the following: absence of health, economic or environmental constraints on growth, adherence to MGRS feeding recommendations, absence of maternal smoking, single term birth (259 - 294 days), standard paediatric care and absence of significant new-born morbidity (6). The criteria for compliance with feeding recommendations were the following:

- Exclusive or predominant breastfeeding for at least 4 months (120 days) (administration of minerals, vitamins and medicines permitted);

- Introduction of complementary foods by the age of 6 months (180 days);
- Partial breastfeeding to be continued for at least 12 months (365 days);

In the longitudinal part of the study, the children's measurements were taken at home, in total 21-times (at weeks 1, 2, and 6; thereafter monthly; and from 1 to 2 years of age every two months). In addition to the anthropometric measurements and data about motor development, information about socio-economic, demographic and environmental characteristics as well as prenatal factors and nutritional practices were collected (6). MGRS took place in six countries: Brazil, Ghana, India, Norway, Oman, and the USA.

The current NCHS/WHO international reference data based on the North American population will thus be replaced by new, truly international standards for height, weight and weight for length/height. Furthermore, new standards will be developed for triceps and subscapular skinfolds, head and arm circumferences, and body mass index. Such data are particularly important for the monitoring of the rapidly spreading epidemic(s) of child obesity.

The longitudinal component of the study will also allow the development of standards for monitoring the growth velocity of various body characteristics. This will make it possible for paediatricians to predict under- or over-nutrition before children become undernourished or obese.

Simultaneously, reference data on motor development will be published, providing a unique link for assessing physical growth together with motor development.

The new standards will be available for children up to 5 years of age. It is evident that this effort needs to be expanded to older children. Early in 2006 WHO will provide growth standards for body height/length, body weight, weight for height and BMI. Other data will be available before the end of 2006.

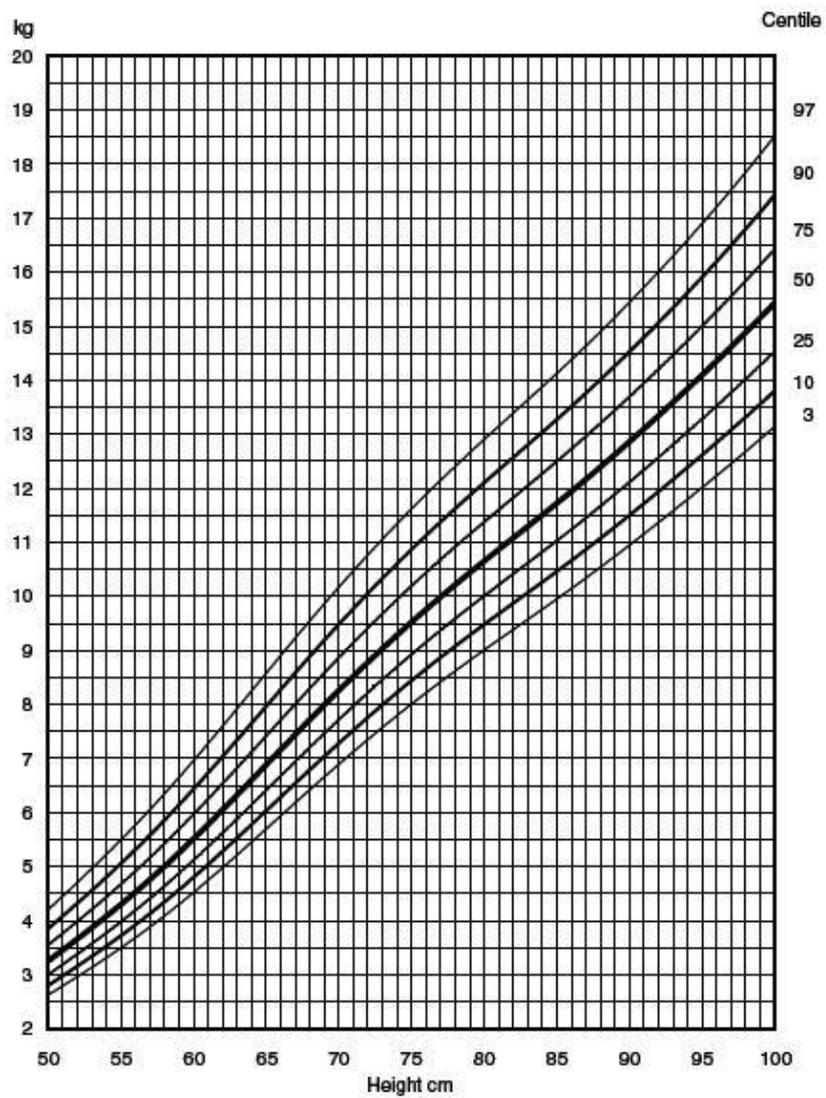


Figure 3b – Czech reference weight for height growth chart, girls, 50–100 cm.

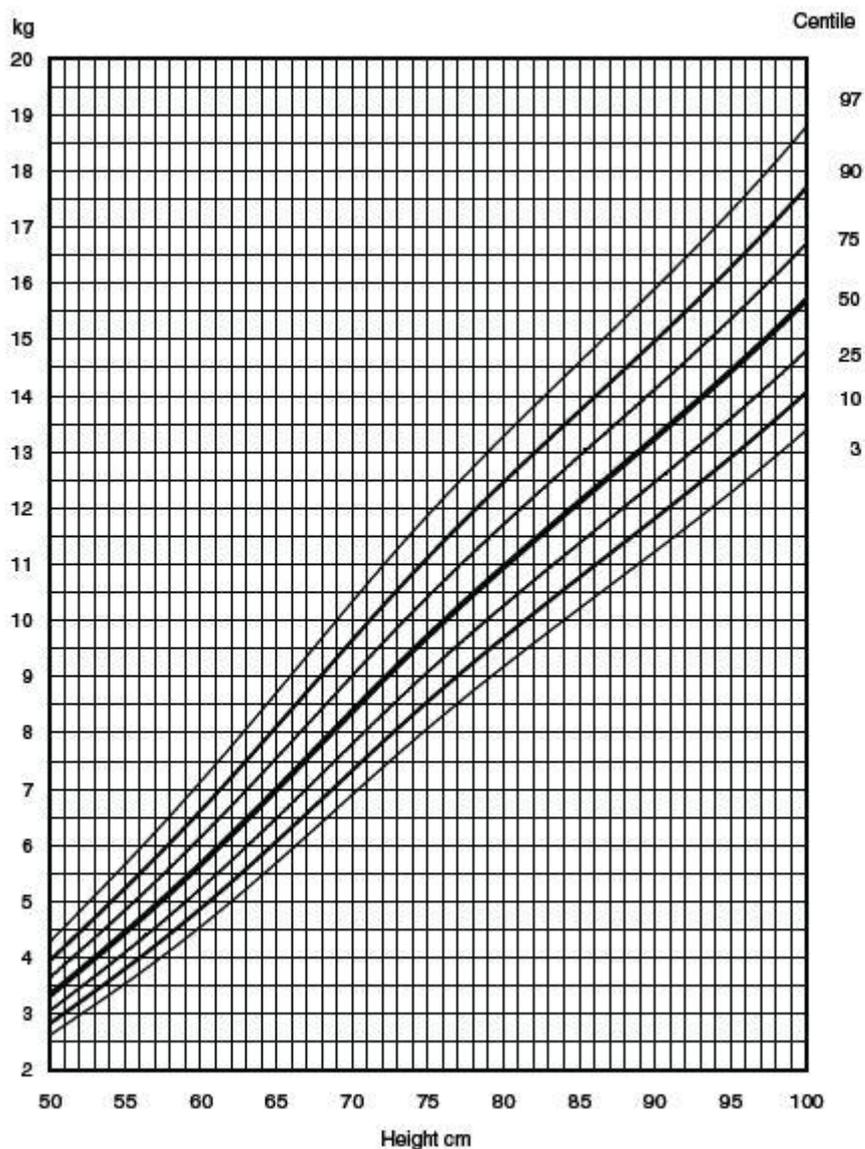


Figure 3a – Czech reference weight for height growth chart, boys, 50–100 cm.

Overweight and Obesity

If BMI centile charts are constructed for a population with higher prevalence of overweight and obesity, then the centile lines, mainly for the 90 and 97 centiles, will show higher BMI values in comparison with those obtained for a population with lower prevalence of overweight and obesity. The same problem needed to be addressed when BMI centile charts from 1991 for the Czech population of children were updated based on the 6th nationwide anthropological survey conducted in 2001.

As the prevalence of overweight and obese children has recently been increasing, particularly in age groups from 6 to 13 years, it is reflected in an upward trend of the 90 and 97 centiles (Figures 4a, 4b). Since the 90 and 97 centiles from 1991 were considered as the

limits of overweight and obesity, respectively, for purposes of both individual assessment and epidemiological studies, the limits based on newer data would be shifted toward higher values and consequently, interpretation of overweight/obesity would be biased. For this reason we decided to continue using the BMI centile charts from 1991.

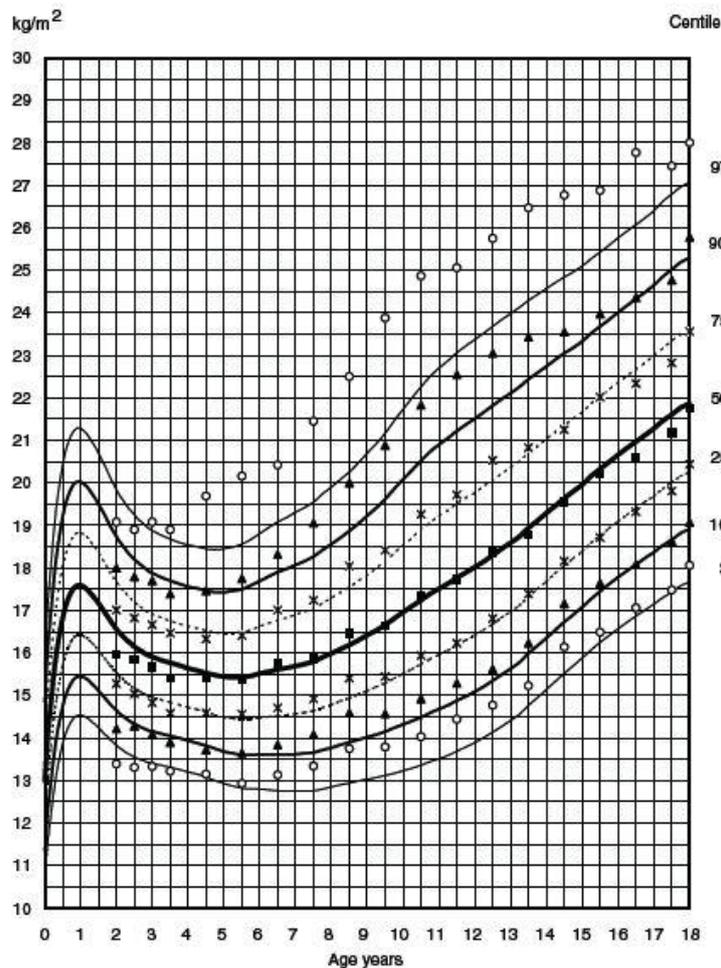


Figure 4a – Centiles based on 2001 nationwide anthropological survey (points), compared to Czech reference BMI growth chart 1991 (lines), boys, 0–18 years.

In 2002, Centre for Disease Control and Prevention issued growth charts including BMI charts recommended for the American population. As this population is characterized by high prevalence of overweight and obesity, the 85th centile was selected as the limit for overweight: it represents slightly lower values compared to the 90th centile for the Czech population.

In 2000, Cole constructed centile charts recommended for international use, based on several studies. He assumed that the BMI limits for overweight and obesity in 18 years olds are 25 and 30, respectively. Therefore, he constructed the 90th and 97th centile curves to correspond to the BMI limits as indicated above. Nevertheless, in practice these limits proved too high and the respective charts in epidemiological studies showed lower prevalence rates of

overweight and obesity. Since other internationally usable reference data have not been available to date, these charts are currently used in international comparison of overweight and obesity prevalence. A universal standard is needed to which the obtained data could be related.

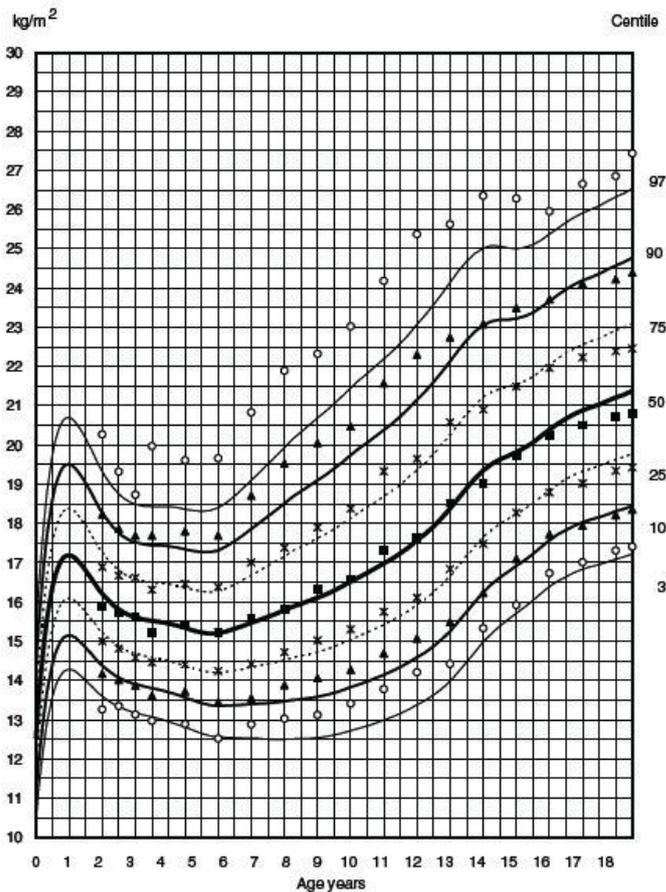


Figure 4b – Centiles based on 2001 nationwide anthropological survey (points), compared to Czech reference BMI growth chart 1991 (lines), girls, 0–18 years.

It is to be noted that the 25, 50 and 75 centile curves in all reference charts are almost congruent while peripheral values differ. As it was already said, the charts vary depending on the population for which they are constructed, i.e. on the prevalence rates of overweight but also underweight population. At the same time, another important factor is the mathematical method used to smooth centile curves. Problems are usually posed by the construction of peripheral curves, i.e. the 3 and 97 centile curves that may be distorted and may not reflect reality.

Another problem is, despite every effort made, failure to determine empirically the BMI limits for normal weight, overweight and obesity in children and adolescents. Some overweight teenagers are mistakenly classified into the 90th centile (false negativity) while normal weight teenagers may be mistakenly classified into the channel above the 90 centile

(false positivity). The same is true of the 97th centile. The underweight limit is neglected in the literature. Ideally, the centile chart should minimize false negative and false positive classification.

For clinical purposes, diagnoses of overweight and obesity are complemented with indication of some body characteristics, mainly waist circumference, and selected skin fold values, while in adolescents, body fat proportion is determined by additional methods such as magnetic resonance (MR), bioelectrical impedance analysis (BIA), dual energy X-ray absorptiometry (DEXA), etc. In paediatric practice, the arm circumference appeared unusable and waist circumference is to be related to body height rather than to age. Skin fold measurements require the use of caliper and specific skills.

1.2 How to Monitor Body Growth in Childhood

For common assessment of body growth, height, weight for height and BMI are most frequently used. Under favourable conditions leading to full development of the genetic potential, i.e. when adequate healthcare, nutrition and socio-economic conditions are available, the growth in childhood corresponds to the recommended reference data. This means that the growth curve of the followed up child is parallel to centile curves in the range of the 25th to 75th centiles. Possible forms of growth curves in comparison with the reference ones are represented in Figures 5a, 5b and 5c.

At follow-ups, the measured values are plotted in charts as points. To be more illustrative, a curve is drawn through the plotted points, representing an individual growth curve for the child monitored. At longer follow-up intervals, this curve is a subsidiary line and does not reflect the actual growth process.

Figure 5a shows the growth curve for an even development of a given body characteristic. Figure 5b shows stopped growth and may be suggestive e.g. of a growth disorder. If the monitored parameter is body weight, e.g. while on a weight reduction diet, the result is read as positive.

Figure 5c shows a clear rise in the characteristic monitored that can be observed in puberty, and is acceptable if related to body height but alarming if related to body weight (WHO 1986).

If a child's growth curve is parallel to centile curves beyond the range of the 25th to 75th centiles, the parents' body height and build should be taken into account. If the curve reaches peripheral centile channels, the assessment varies with the body characteristic studied.

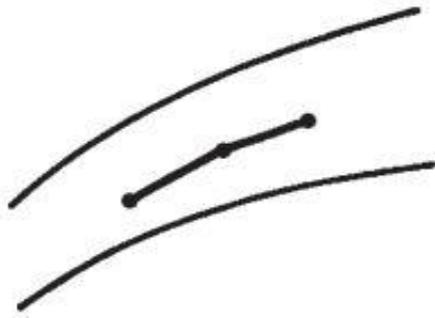


Figure 5a – Even growth.



Figure 5b – Growth is slowed down to stopped.

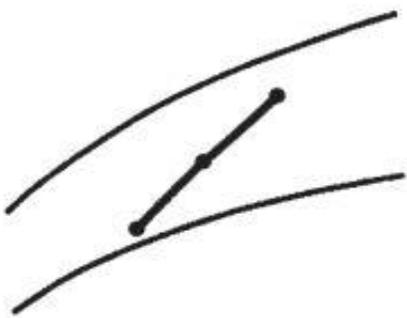


Figure 5c – Accelerated growth.

3. Discussion - Child Growth Assessment Based on Growth Charts

In this part, growth assessment based on centile charts is described as used in paediatric practice in the Czech Republic. The assessment does not vary considerably from country to country while the reference data used may fluctuate.

The centile curves divide the chart into five channels, classifying children at any age by body height, weight to height ratio and BMI within the following scale (Table 2). Note: Assessments by body weight to height ratio and that by BMI may not correspond.

Body height (length): A child's body height is strongly dependent on his/her parents' heights and this is to be taken into account in the assessment. The puberty period, the onset of which varies widely, is also characterized by accelerated growth.

Body weight to height ratio and BMI: Individuals whose body weight to height ratio or BMI range between the 75th and 90th centiles are overweight. Values close to the 90th centile are marks of overweight to obesity, usually associated with excessive fat mass development, values above the 95th to 97th centiles are unambiguously mark of obesity. Values below the

25th centile correspond to reduced weight and values below the 3th centile are alarming and underlying causes need to be identified (e.g. food intake disorders are to be considered in this regard). In adolescent boys, mass development should be taken into account. Higher BMI values may not always indicate increase in fat mass. In any case, if BMI is higher than the 85th centile, the fat mass content should be analysed. The above mentioned facts do not apply to infants whose body weight depends on how they are fed. Breastfed infants have lower weight compared to those either partly or fully bottle fed. In children aged up to 6 or 10 years, body weight for height charts can be used while BMI charts are suitable for older children.

Table 2 Classification of the child's growth by height and body weight (weight for height)

Centile	Classification	
	By body height	By body weight for height and BMI
Channel above 97 centile	very tall	obese (from 95 centile)
Channel above 90 centile		overweight
Channel between 75 and 90 centiles	tall	plump
Channel between 25 and 75 centiles	medium	proportionate
Channel between 3 and 25 centiles	short	thin
Channel below 3 centile	very short	underweight

Head circumference: Head circumference is one of the parameters measured in children immediately after birth. This parameter is routinely monitored in children at preventive paediatric check-ups. Head circumference should be considered in relation to the child's body build, i.e. to body height and weight as well as to his/her general development. When considering values, the head circumferences should be taken into account as a strong hereditary factor.

Arm, hip circumferences: Monitoring of these parameters can partly replace the skin fold measurement which is more exacting instruments. Interpretation of centile charts for these circumferences corresponds to information obtained from height to weight ratio charts and BMI charts.

Marked differences between centiles for a child's particular circumferences are suggestive of uneven distribution of his/her subcutaneous fat tissue. In individuals with a higher proportion of mass, this fact should be taken into account in the assessment of both the circumferences and BMI.

Follow-up of these circumferences in overweight and obese individuals is helpful in the assessment of the progress in weight reduction. Nevertheless, fast weight loss with rapid reduction of circumferences can be associated with mass loss requiring revision of the weight reduction programme used.

4. Conclusion

Regular child growth monitoring is part of everyday paediatric praxis. Growth charts are helpful in the assessment of how a breastfed child's physiological needs are met in the first six months of life. Head circumference monitoring is an integral part of growth follow-up of children under 3 years of age. Early recognition of a growth disorder, overweight or other deviations in children at preschool and school age can more serious illness marks in later age.

An adequate growth assessment is only feasible if up-to-date growth charts for basic body characteristics, i.e. body height, head circumference and BMI are available. Charts for other body characteristics are used in clinical centres, most frequently as part of software packages developed for specific purposes.

5. References

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6. Contact

Assoc. Prof. RNDr. Pavel Bláha, Ph.D.

College of Physical Education and Sport PALESTRA

Pilská 9, 190 00 Prague, Czech Republic

E-mail: blaha@palestra.cz