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CHILD GROWTH NATIONAL STANDARDS IN CZECHOSLOVAKIA

M. Prokopec
Institute of Hygiene and Epidemiology, Praha, Czechoslovakia

Abstract: The growth of children and adolescents in Czechoslovakia has been systematically investigated by nation-wide growth surveys, undertaken since 1951 at intervals of 10 years on a random sample of children between 0 and 18 years. Due to the secular trend demostrated by these surveys, the 1951 standards as used in the child health service, ceased to reflect reality as early as 1971. In that year the average height in the individual age groups of school children deviated from the 1951 standard by about 0.5 S.D. A new standard for assessing height and body proportions of boys and girls from 3 to 18 years of age has been established in the form of tables and charts based on the 1981 survey (for the Czech districts). Examples of how to use the charts in paediatrics (following the growth of an individual child) and in the public health service (following the distribution of height and body proportions and the state of nutrition in groups of children) are given. Data on height and weight of the Czech children and youth in 1981 from 0 to 18 years are given in the enclosed tables 1–4.

Key words: Growth standards, Paediatrics, Children's body proportions.

Introduction

It is well-known that even an experienced pediatrician cannot assess reliably a child's growth at a given age without appropriate growth standards (Tanner 1978). Despite the fact that Matiegka* (1927), with help of teachers, had accomplished an examination of about 100 000 Czech schoolchildren as early as in the year 1895, until the beginning of the second half ot the 20th century the growth of Czechoslovakian children was assessed according to foreign (American after Woodbury and Baldwin) and Austrian (after Pirquet) standards. An extensive investigation comprizing over 120 000 Czech children (a random sample of 4%) between 3 and 18 years of age was executed under the guidance of V. Fetter in the year 1951, when it was deemed necessary to obtain reliable national standards for the evaluation of the growth of children. Moreover the investigation was set up to elucidate the question whether or not the World War II had depressed the growth of children and adolescents. Consecutively to this investigation, three additional nation-wide growth suerveys have been executed to date. With intervals of 10 years, these were made comprising children from 0 to 18 years in the years 1961, 1971 and 1981, for the Czech and Slovakian regions separately. The results always demonstrated a progressive secular growth trend in the Czechoslovakian samples. As early as in 1971 it appeared that the 1951 growth standards, which were used in school health records, had ceased to correspond to reality (Prokopec et al., 1973, Prokopec 1985).

*Jindřich *Matiegka* (31.3.1862 – 4.8.1941) was the lst professor of anthropology and demography on the Charles' University in Prague and the founder of modern anthropology in Czechoslovakia. He also founded with paedagogists F. Čáda and J. Dolenský and with K. Herfort, a psychiatrist the Institute for the study of child and youth development in 1910 in Prague. Besides his extensive child growth survey in 1895 Matiegka introduced "dental age" into assessment of child development in early 1920th, stereophotogrammetry (with Prof. Pantoflíček) into physical anthropology as early as 1910 and has a World priority in developing the study of body composition "in vivo" by means of external measurements including skinfolds in 1921 (Am. J. Phys. Anthrop.).

Table 1. Czech National Standards – 1981. Boys' stature (M. Prokopec – S. Titlbachová)

Age (months/years)	N	M	S.D.
1 month	730	54.31	2.94
2	579	58.31	3.32
3	605	61.58	3.33
4	583	64.65	3.27
5	612	66.92	3.21
6	574	69.39	3.37
7	597	70.70	3.18
8	612	72.15	3.17
9	555	73.46	3.23
10	578	74.46	3.06
11	545	75.85	3.23
1 year	1661	76.97	3.56
1.25	1844	80.02	3.60
1.5	1784	82.96	3.60
1.75	1688	85.75	3.78
2	2770	88.07	4.10
2.5	2531	92.85	4.10
3	2214	96.87	4.14
3.5	2441	100.67	4.34
4	3972	103.51	4.95
5	2885	110.97	5.22
6	2339	117.28	5.59
7	2349	123.30	5.46
8	2351	129.22	5.87
9	2341	134.56	6.24
10	2257	139.88	6.45
11	2225	144.97	6.89
12	2289	150.50	7.27
13	2435	157.17	8,57
14	2243	164.60	8.81
15	2301	171.28	7.93
16	2543	175.21	7.16
17	2413	177.20	6.71
18	2006	178.26	6.83

Table 2. Czech National Standards – 1981. Girls' stature (M. Prokopec – S. Titlbachová)

Age (months/years)	N	M	S.D.
1 month	724	53.14	2.63
2	563	56.73	3.21
3	624	59.85	3.15
4	567	62.70	3.14
5	600	65.46	3.15
6	609	67.40	3.17
7	567	69.13	3.18
8	616	70.30	3.20
9	531	71.72	3.35
10	600	73.12	3.23
11	575	74.13	3.49
1 year	1668	75.28	3.47
1.25	1811	78.52	3.44
1.5	1872	81.67	3.79
1.75	1712	84.26	3.86
2	2822	86.74	4.14
2.5	2523	91.79	4.39
3	2203	96.13	4.25
3.5	2451	99.76	4.37
4	3975	103.09	4.93
5	2876	110.44	5.36
6	2474	116.74	5.51
7	2266	122.78	5.45
8	2437	128.34	5.88
9	2341	133.91	6.20
10	2269	139.47	6.58
11	2280	145.71	7.43
12	2330	152.28	7.60
13	2485	158.03	6.96
14	2233	162.10	6.51
15	2486	164.13	5.87
16	2832	164.69	5.95
17	2884	165.07	5.78
18	2418	165.35	5.83

Table 3. Czech National Standards – 1981. Boys' weight (M. Prokopec – S. Titlbachová)

Age (months/years)	N	M	S.D.
1 month	730	4.14	0.64
2	579	5.19	0.76
3	605	6.14	0.86
4	583	6.98	0.82
5	612	7.66	0.88
6	574	8.22	0.92
7	597	8.72	0.91
8	612	9.05	1.00
9	555	9.52	1.09
10	578	9.84	1.06
11	545	10.16	1.17
1 year	1661	10.42	1.26
1.25	1844	11.11	1.22
1.5	1784	11.82	1.35
1.75	1688	12.34	1.41
2	2770	12.90	1.49
2.5	2531	14.02	1.60
3	2214	15.04	1.73
3.5	2441	16.14	1.89
4	3972	17.02	2.07
5	2885	19.21	2.45
6	2334	21.64	3.14
7	2349	24.09	3.64
8	2351	27.07	4.40
9	2341	30.23	5.36
10	2257	33.65	6.19
11	2225	37.23	7.13
12	2289	41.09	7.89
13	2435	46.79	9.57
14	2243	52.71	10.14
15	2301	58.96	9.59
16	2543	63.97	9.33
17	2413	67.29	8.98
18	2006	69.74	8.48

Table 4. Czech National Standards – 1981. Girls' weight (M. Prokopec – S. Titlbachová)

Age (months/years)	N	M	S.D.
1 month	724	3.84	0.54
2	563	4.73	0.64
3	624	5.59	0.70
4	567	6.40	0.77
5	600	7.11	0.85
6	609	7.60	0.85
7	567	8.08	0.87
8	616	8.47	0.97
9	531	8.83	1.08
10	600	9.23	1.05
11	575	9.39	1.11
1 year	1668	9.75	1.16
1.25	1811	10.48	1.19
1.5	1872	11.11	1.30
1.75	1712	11.72	1.36
2	2826	12.27	1.47
2.5	2523	13.47	1.61
3	2203	14.56	1.76
3.5	2451	15.58	1.90
4	3975	16.51	2.16
5	2876	18.77	2.78
6	2474	21.15	3.19
7	2266	23.70	3.81
8	2437	26.62	4.46
9	2341	29.85	5.46
10	2269	33.37	6.35
11	2280	37.61	7.71
12	2330	43.23	9.26
13	2485	48.25	9.21
14	2233	52.77	8.74
15	2486	55.87	8.16
16	2832	57.78	8.33
17	2884	58.87	7.71
18	2418	59.08	7.94

Therefore on the basis of the results of the 4th nation-wide anthropometrical research from the year 1981 (for the Czech districts) new tables were compiled to be used as a new growth standard (Table 1–4). On basis of these tables, new percentile charts, were developed at the Institute of Hygiene and Epidemiology in Prague by Prokopec and Roth (Figures 1 and 2).

Growth Standards

Description of the charts: The Assessment of Height

The charts were drawn separately for boys (Figure 1) and for girls (Figure 2). The principle of both charts is the same. The measured height of the child (from 3 to 18 years) is evaluated from the upper part of the chart in relation to age. The body proportions, i.e. measured weight for height are evaluated from the lower part of the chart. Age is registered on the horizontal scale at the top of the charts, height on the vertical one. The curves represent the boundaries of the bands as determined by selected percentiles. For example 3 per cent of the children in the given age category from the group which has been submitted for measurement are under the curve denoted by the third percentile. The drawn curves form three bands, which are divided in halves by the dashed curves. By plotting into them the individual values of height and age, the charts render it possible to classify the child in one of the five height categories: I= very tall, II = tall, III = of medium height, IV = small, V = very small.

A more accurate evaluation of the height can be obtained by estimating the deviation of the child's position in the grid from the median 50th percentile curve (thick dashed line – M) at given age expressed in fractions (decimals) of the band's width (B. W.) at that age. Band's width (the distance between the two thick curves at given age) equals approximately 1.2 S.D. of the mean height at given age. In case of extremely tall or extremely small child for its age whose height lies either in the area I or IV, we may estimate the distance of the child's position from the 50th percentile by extrapolation using the width of the band at given age as a measure (Table 5).

The heavily dotted line in the Figures 1 and 2 which is not a part of the chart represents the abandoned 1951 standard – a visual comparison with the 50th percentile dashed curve of the 1981 standard is possible in this way.

The Assessment of Body Proportions

In the lower part of the charts height is marked on the horizontal axis and weight on the vertical axis. The weight scale is logarithmic, to economize on space. In this way the curves become linear, and can be fitted into the charts. The curves divide the lower part of the charts into five categories denoted by letters A, B, C, D, E according to the body proportion of the child in question: A = fat or obese, B = robust, C = well-proportioned, D = thin, E = very thin.

For more accurate evaluation we use again fractions of the band width at given centimetre of height. The way of assessing the deviation of the child from the 50th percentile median curve is similar as it was when assessing height in the upper part of the grid (Table 6).

Again, the heavily dotted curve drawn in the lower portion of the chart (which is not a part of it) represents the 1951 mean height-weight ratio, showing the secular change in mean body proportions when compared with the 1981 fifty percent curve. Girls show a more distinct tendency towards thinning than boys (see Figures 1 and 2).

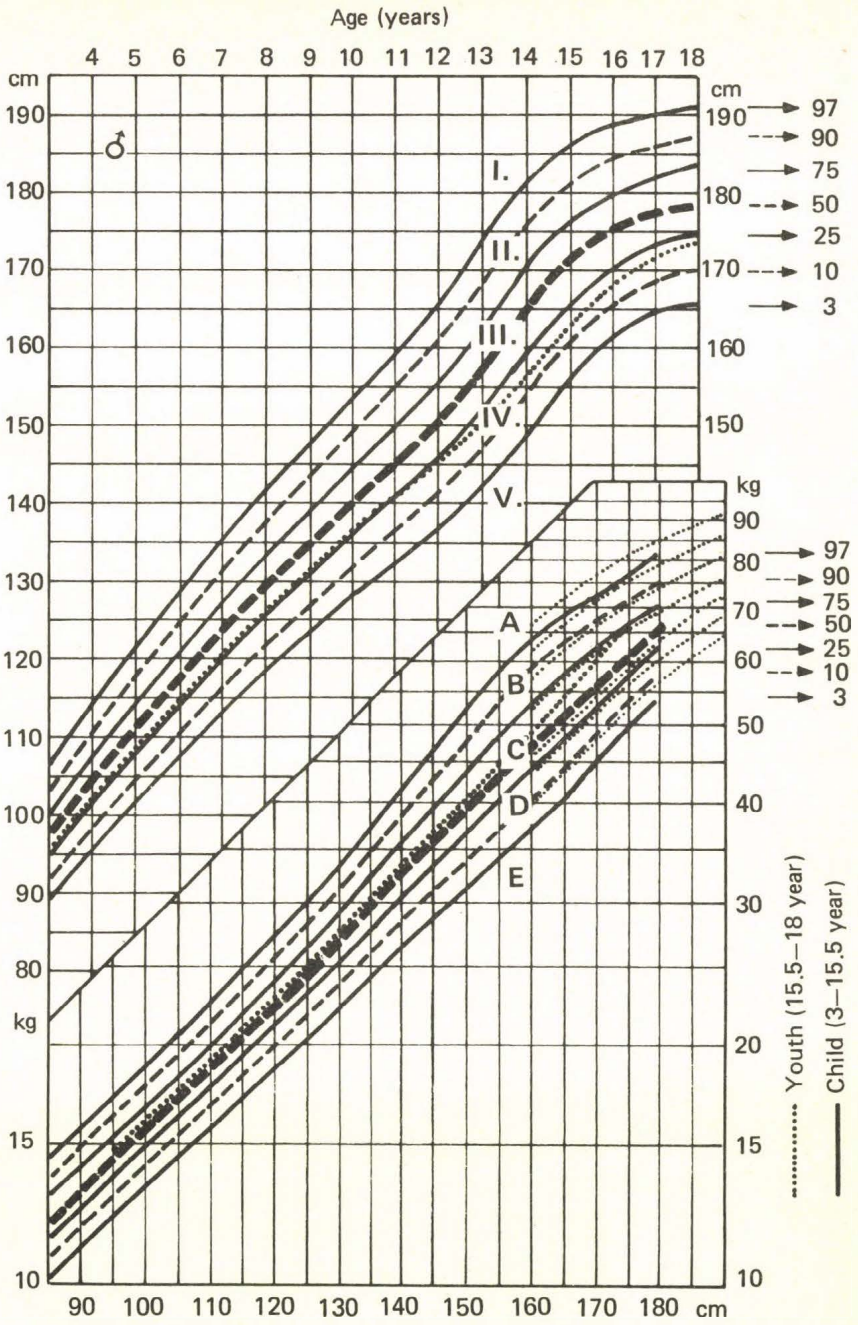

Fig. 1: Percentile chart for the assessment of height for age (upper part) and weight for height (body proportions; lower part) in boys. The heavily dotted lines represent the standards of 1951. For a further legend: see text

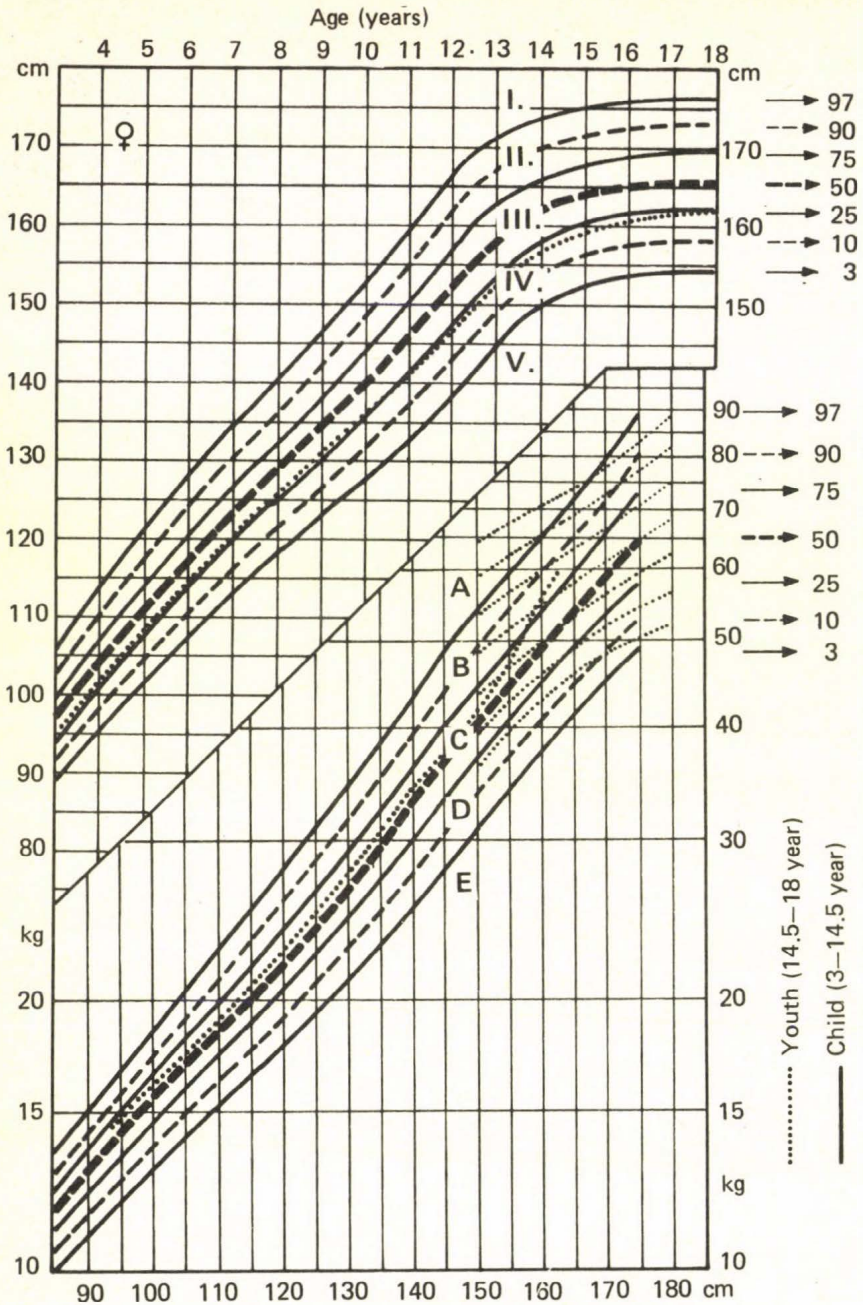

Fig. 2: Percentile chart for the assessment of height for age (upper part) and weight for height (body proportions; lower part) in girls. The heavily dotted lines represent the standards of 1951. For a further legend: see text

Table 5. Height categories

	Height category	Percentiles	Expected number of children in percent	Fractions of band width
I	Very tall	over 97th	3	M+1.6 and more
II	Tall	75th to 97th	22	M+0.6 to M+1.5
III	Of medium height	25th to 75th	50	M−0.5 to M+0.5
IV	Small	3rd to 25th	22	M−0.6 to M−1.5
V	Very small	below 3rd	3	M−1.6 and more

Table 6. Categories of Body Proportionality

	Category of Body Proportionality	Percentiles	Expected number of children in percent	Fractions of band width
A	Obese	over 97th	3	M+1.6 and more
B	Robust	75th to 97th	22	M+0.6 to M+1.5
C	Well-proportioned	25th to 75th	50	M−0.5 to M+0.5
D	Thin	3rd to 25th	22	M−0.6 to M−1.5
E	Very thin	below 3rd	3	M−1.6 and more

The use of the charts

Important data which are necessary to a child's assessment are: (1) its accurate age in years and months (or decimals of the year), (2) its height, determined by measuring the child without any footwear in a maximum erect posture with its heels together, the head positioned to look into far distance, i.e. with the position of the head on the Frankfurt plane, and (3) its weight by means of accurate scales (not using a spring system).

By plotting the height for age in the upper part of the appropriate chart, we are able to evaluate the child's height by means of the symbols I–V, according to the position of the point, representing the child in the proper band. The height may be more accurately defined by using the band widths.

After plotting the weight for height values into the lower part of the chart we are also able to read the body proportions. In compliance with the position of the point representing a given child in the bands of the chart we may evaluate his or her body proportions, designating it by one of the letters (A–E). If we want to express its proportions more accurately, we may use the auxilliary dashed curves and express the deviation of the child from the 50th percentile curve in fractions of band widths or by the corresponding percentiles.

Example: Ann is 10 years old. She is 145 cm tall. After plotting her height into the grid we find out that she is in the II category of body height. We may assess her more accurately as being M+0.6 B. W. above the 50th percentile curve. Supposing that she adds 10 cm to her height in the course of a year, she will remain at 11 years with her 155 cm in the II category. Her deviation from the median 50 th percentile curve will be + 1.1 B. W.

Ann's weight at 10 years was 43 kg. When plotted in the lower part of the grid jointly with her height she finds herself in the B category as "robust". She deviates from the 50th median percentile curve by M+0.8 B. W. At 11 with her 48 kg and 155 cm she moved to category C as "well-proportioned", her position in the grid being M+0.4 B. W.

Ann was assessed in symbols at 10 as II/B and at 11 as II/C.

The relation of weight to height changes with the child's age: Out of two children, equally tall, the older child tends to be heavier, starting after about the age of 12 in girls and 14 in boys. The curves characterising the group of older children: boys between 15 and 18 and girls between 14 and 18 years old are represented by a series of thin dotted lines at the upper and of the weight curves. Their course is different, especially in girls. The order of the bands remains and their use is the same. The fact that the percentiles were calculated from the age 3 to 14 years makes the grid slightly a less sensitive to very thin and very heavy (obese) children from younger age groups.

The information about the individual child, to be derived from the charts

The possibilities of practical use of the percentile evaluation charts are the following: (1) It is possible to evaluate each child within the framework of the bands. The child may be designated by a formula representing his or her height and body proportions, i.e. by a Roman numeral and a capital letter. Should we want to make its evaluation more accurate, we are obliged to determine its position within the appropriate band. The band is then considered as the evaluation unit, in the same way as was the standard deviation (S.D.) in the former charts (Kapalin and Prokopec 1957). A precise reading (calculation) of percentiles from the chart is uneasy, even not possible because there are different numbers of percentiles in the various bands. (2) If a boy or a girl has been measured regularly, the individual growth curve may demonstrate his or her longitudinal bodily development against the background of the total population of children. In this way we may evaluate the dynamics of the growth of an individual child. This is convenient for the clinical practice, the school health service, for the determination of the relative date of the onset of puberty, etc. The puberty period in the individual child has a shorter duration than is indicated by the accelerated slope of the growth curves on the chart, which represent the whole population of children. Therefore, the growth curve of an individual child most frequently deviates temporarily from the general course of the standard height curves and after about two to three years returns to the position in the band which it occupied before the growth spurt started. The diagnosis of an early or late maturer is possible by comparing the individual growth curve with the standard. This may serve for the selection of athletes, etc.

The information on specific groups within the children's population, to be derived from the charts

The percentile charts renders it possible to evaluate a collective of children (a school class, etc.), which is not homogeneous with regard to age or which even consists of both sexes together (group diagnosis). By calculating the percentages of children in the separate height or body proportion groups (bands) we may obtain, by means of a simple table (Fig. 3), an idea about the growth, variability or homogeneity of the given group and even to a certain extent about its level of nutrition and other factors. Expected (theoretical) relative numbers of children (percentages) in individual bands I–V for height and A–E for body proportionality are als follows: I/A = 3 per cent, II/B = 22 per cent, III/C = 50 per cent, IV/D = 22 per cent, V/E = 3 per cent. Any substantial deviation of this scheme found in a studied group of the Czech children should be a reason for being concerned and for a raised attantion.

This practical use of the chart is demonstrated by an example of 4 girls and 4 boys. Figure 4 shows 4 selected girls: 1 = slender, 2 = well-proportioned, 3 = robust and 4 = of delayed growth. Their individual data are presented in Table 7. The girl No. 4 appears to be a well-proportioned child according to the lower part of the chart as well as by visual assessment. However, if we relate the value of her height to her calender age, she is very

Table 7. Height, weight and body proportions of four girls

Number of the girl	Age	Height	D1*	Weight	D2*	Assess-ment
1	13y. 1m	157.0 cm	− 0.2	39.0 kg	−1,0	III/D
2	12y. 1 m	153.0 cm	0	41.5 kg	−0.2	III/C
3	8y. 0 m	123.0 cm	−0.75	30.5 kg	+1.7	IV/A
4	11y. 6 m	126.0 cm	−2.4	23.2 kg	−0.4	V/C

*Deviation (distance) from the 5th percentile curve (M) in fractions of band width at given age for D1 and for given height for D2

small. The average girl of her age would be 149 cm tall according to the 50th percentile curve. Her biological (height) age is 7y, 6m. as shown by a cross-section of the girl's actual height with the 50th percentile curve.

The boys are depicted in Figure 5, and their data are presented in Table 8. The boy No. 4 shows an accelerated growth, in contrast to the delayed girl. He exceeds his peers of medium stature by 14cm, the mean stature for a boy of 12y, 5m. being 154 cm. The silhouettes of the children in Figures 4 and 5 were all made at the same scale, so that their heights and body proportions are mutually comparable.

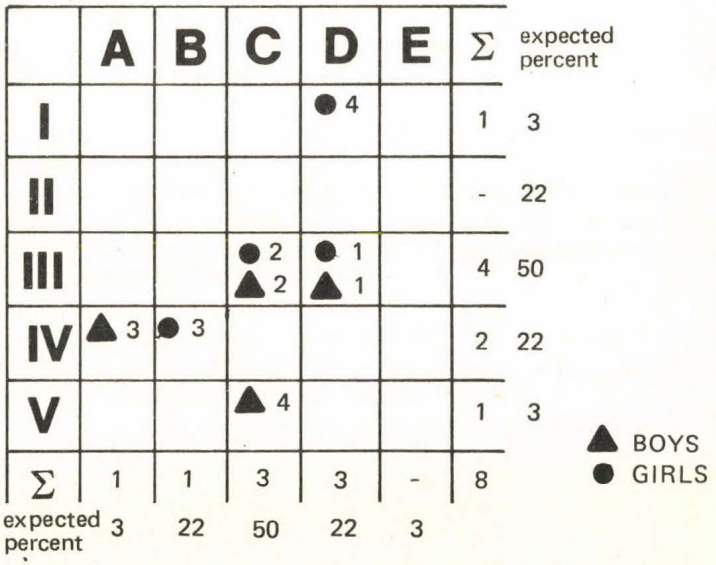

Fig. 3: Example of a group diagnosis after Kapalín and Prokopec (1957) of eight children assessed by the charts according to their stature and body proportions. The variation of both attributes in a collective of children may be expressed in percentages and the eventual deviation from the distribution in the total population of children may be tested by the χ^2 method. (Calculation of per cent frequencies in our case of eight children only is of course irrelevant.)

Table 8. Height, weight and body proportions of four boys

Number of the boy	Age	Height	D1*	Weight	D2*	Assess-ment
1	12y. 2m	153.3 cm	+0.1	38.0 kg	−0.6	III/D
2	12y. 9 m	153.8 cm	−0.25	40.0 kg	−0.4	III/C
3	12y. 6 m	148.0 cm	−0.6	47.5 kg	+1.25	IV/B
4	12y. 3 m	168.0 cm	+1.6	49.8 kg	−0.6	I/D

*Deviation (distance) from the 50th percentile curve (M) in fractions of band width at given age for D1 and for given height for D2

Final Remarks and Discussion

The evaluation percentile charts represent the output of the IVth nation-wide child growth survey (for the Czech districts). It has shown clearly that the standard applied in the health service since the year 1951 is no longer valid. The innovative aspects of these charts is the use of percentiles instead of standard deviations. An advantage of the evaluation by means of charts as compared to that of tables is the possibility of an optical control of the position of the child in the grid, an evaluation of the dynamics of the child's development, if it is measured regularly and the possibility to classify each child according to its accurate age. Figure 3 shows the way in which individually assessed children of different ages (and also of both sexes) may be evaluated as a group using their symbols of body height and body proportions. In this way V. Kapalín evaluated groups of children, which he used as a sensitive detectors of the quality of environmental, social and nutritional living conditions already in late sixtieth.

The validity of the newest Czech growth standards from 1981 may be longer than those from 1951, because the secular trend is expected to slower down in the near future with increased rapidity. The chart for assessing growth and physique, which has been just described represents the first draft; it undergoes testing in paediatric practice at present. It has still several weak points. One of them is the sharp transition from the lower to the higher age category at 15 years in boys and at 14 in girls. Other is a certain inaccuracy based on the use of the logarithmic scale in the lower grid. When assessing deviation of the child from the 50th percentile curve, one must keep in mind that in the plus direction it is in reality bigger than it visually seems to be and vice versa the deviation in the minus direction seems to be bigger than it actually is. No allowance for the log scale is taken when calculating the distance from the medium 50th percentile curve using the band widths.

Nevertheless, the system works and is already in its present state of development an invaluable aid in evaluating growth and physique in healthy and sick children to everybody who spends some time using it.

As soon as one makes himself familiar with the system of categories for height and body proportions and with the use of the symbols, one can easily visualize each child (its stature and physique) just when seeing its symbols. He learns to know the meaning of each particular pair of symbols (for height and for height-weight ratio), that i.e. I/A is a very tall and very heavy built child, III/C a child of a medium stature and of balanced proportions, III/D a child of a medium stature and thin, etc.

It is not a rare case in the school medical service that a mistake either in measuring or recording the data has been discovered on the basis of discrepancy between what the investigator had in mind when hearing or reading the symbols of particular child and what he saw.

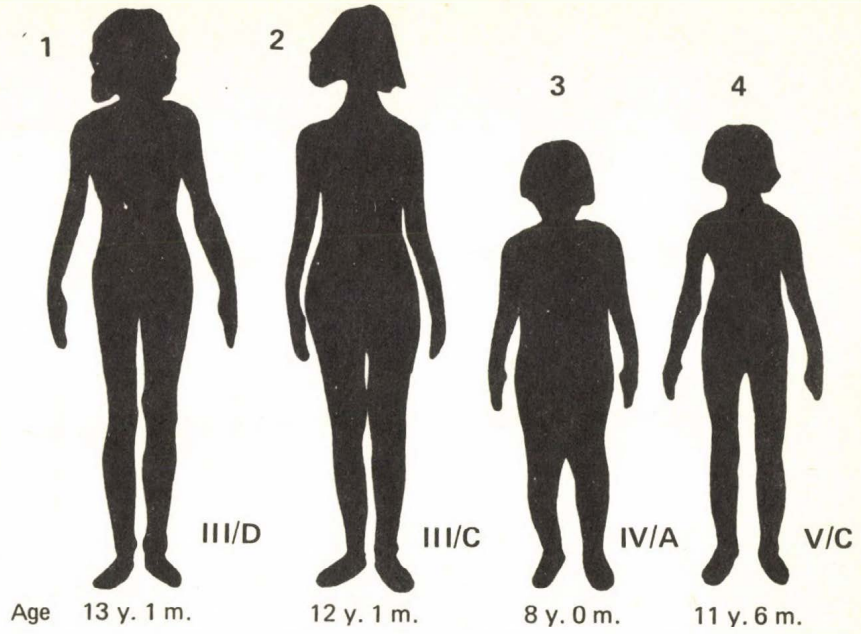

Fig. 4: Example of four girls assessed by the chart, with their symbols for height and body proportions. For details see text

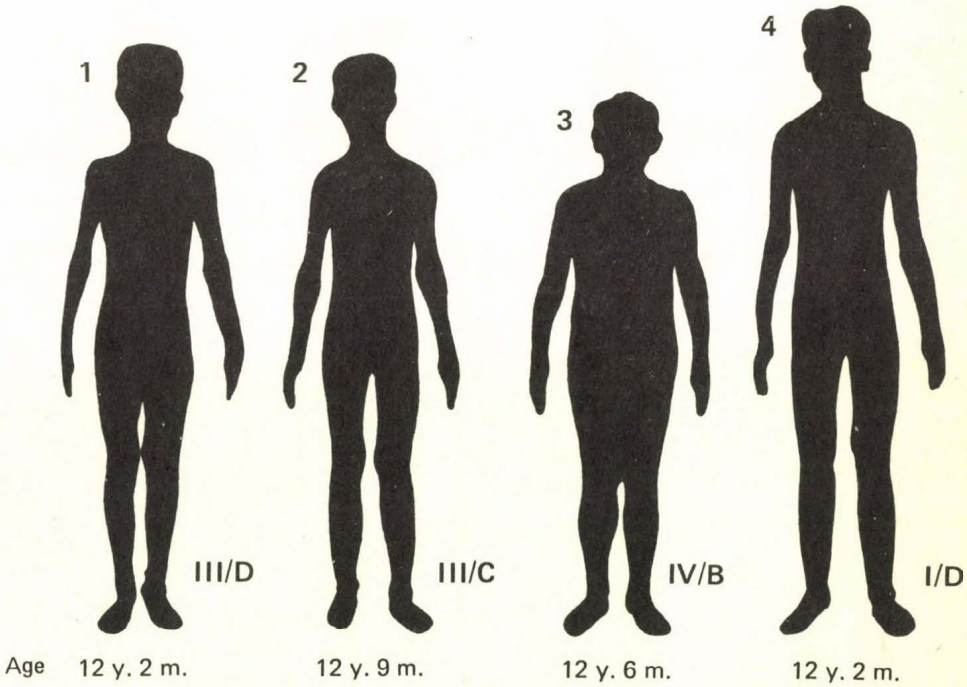

Fig. 5: Example of four boys assessed by the chart, with their symbols for height and body proportions. For details see text

Table 9. Computer Assessment

Growth level of the children according to age, height, weight and sex

EXAMPLE OF COMPUTER ASSESSMENT of the 4 girls in Fig. 4

1		2	3			4			5		6	7	8	9	10
JMENO		DATUM POHL	MERENI D	M	R	NAROZENI D	M	R	VEK R	M	VYSKA CM	ODCH. SIGMA	HMOTN. KG	ODCH. SIGMA	HM.RL. SIGMA
1		Z	0	0	0	0	0	0	13	1	157.0	−.20	39.00	−1.05	−2.32
2		Z	0	0	0	0	0	0	12	1	153.0	.03	41.50	−.23	−.27
3		Z	0	0	0	0	0	0	8	0	123.0	−.90	30.50	.87	2.25
4		Z	0	0	0	0	0	0	11	6	126.0	−3.07	23.20	−2.03	−.56
N = 4	(11)	PRUMER:							11.17		139.7	−1.03	33.55	−.61	−.23
	(12)	SMERODATNA ODCHYLKA:							2.21		17.7	1.41	8.35	1.23	1.88
	(13)	STREDNI CHYBA PRUMERU:							1.11		8.9	.71	4.18	.61	.94

EXAMPLE OF COMPUTER ASSESSMENT of the 4 boys in Fig. 5

1		2	3			4			5		6	7	8	9	10
JMENO		DATUM MERENI POHL	D	M	R	NAROZENI D	M	R	VEK R	M	VYSKA CM	ODCH. SIGMA	HMOTN. KG	ODCH. SIGMA	HH. RL. SIGMA
1		M	0	0	0	0	0	0	12	2	153.3	.22	38.00	−.49	−.86
2		M	0	0	0	0	0	0	12	9	153.8	−.22	40.00	−.59	−.55
3		M	0	0	0	0	0	0	12	6	148.0	−.77	47.50	.41	1.62
4		M	0	0	0	0	0	0	12	2	168.0	2.19	49.80	.95	−.83
N = 4	(11)	PRUMER:							12.40		155.8	.35	43.83	.07	−.15
	(12)	SMERODATNA ODCHYLKA:							.28		8.6	1.29	5.71	.74	1.19
	(13)	STREDNI CHYBA PRUMERU:							.14		4.3	.65	2.85	.37	.60

1 – name, 2 – sex, 3 – date of measurement, 4 – date of birth, 5 – age in years and months, 6 – height, 7 – normalized deviation (Z-score) of height, 8 – weight, 9 – normalized deviation (Z-score), 10 – normalized deviation of the log body weight from its mean for given cm of height, which expresses the body proportionality, (11) – mean (M), (12) – S. D. of the mean, (13) – med.error of the mean (m).

Computer evaluation of body height and proportionality

A Computer programme has been developed (Z. Roth) for calculating individual deviation from the population means in terms of multiples of Standard Deviation (S.D.) This programme follows closely the graphical way of evaluation given above and besides the evaluation of individuals it provides also means and S.D. for a group of children not necessarily of the same age (and even of the same sex).

The S.D. for weight is presented in two modifications. The first being only the normalized deviation of the mean for a given age and sex, the second is the normalized deviation of the log body weight from its mean for a given height and expresses the height-weight ratio (body proportionality), see Table 9.

This programme is presented in FORTRAN IV and is available also in BASIC.

*

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Mailing address: Dr. M. Prokopec
Institute of Hygiene and Epidemiology
Srobárová 48.
10600 Praha 10. Czechoslovakia