CHILD AND ADOLESCENT LONGITUDINAL GROWTH DATA EVALUATION USING LOGISTIC CURVE FITTING WITH THE USE OF THE DYNAMIC PHENOTYPE METHOD

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A b s t r a c t

Body length and body weight are two forms of the organism's genotype expression. The growth curve of body length in newborns, the growth curve of body height in children and adolescents, and the growth curve of body weight from birth to adolescence express the individual dynamics of the body length and body weight phenotype development. The body length growth curve from birth to maturity is, according to Karlberg, divided into three components: Infancy (I), Childhood (C), and Puberty (P). This paper shows that not only the body length growth curve expressed in length size parameters (D) but also the body weight growth (G) of individual boys corresponds to a growth curve composed of the three I-, C-, P- components expressed by the construction of three separate logistic curves. Each individual logistic curve component distinctly fits, within the defined probability, into the set of the measured phenotype values of body length (D) or body weight (G). Each of the fitted logistic curves is determined by the three constants referred to as the parameters of the Dynamic Phenotype. In the body length growth trait the parameters of the Dynamic Phenotype are (D0, DLi, dDmax) and in the body weight growth trait the parameters of the Dynamic Phenotype are (G0, GLi, dGmax) for each I-, C-, P- logistic curve component. It is shown that the Dynamic Phenotype parameter method described not only determines logistic curve components, but also enables exact construction of the whole individual I-, C-, P- growth curve composed of the corresponding I-, C-, P- sections of the logistic curves. Each I-, C-, P- logistic growth curve component begins by age (t0) and the initial value of the variable (X0) of the I-, C-, P- logistic curve component. The inflexion point of the growth curve component marked by age (t*(X)) indicates the age of the maximal growth velocity of the variables (dXmax). The Dynamic Phenotype method can also be applied to the growth data represented by the average values estimated in the reference groups of probands and to the interpretation of the percentile growth curves.

K e y   w o r d s

Child growth, Dynamic Phenotype; I-, C-, P- logistic curve of body height growth; I-,C-,P- logistic curve of body weight growth

A b b r e v i a t i o n s   u s e d

D, body length or body height; G, body weight; DLi, genetic limit of body length; GLi, genetic limit of body weight; dDmax, maximum velocity of body length growth; dGmax, maximum velocity of body weight growth; G*, weight at inflexion point; t*, age at inflexion point; component (I), Infancy; component (C), Childhood; component (P), Puberty; I-,C-,P- logistic curve

INTRODUCTION

The growth of any variable can be generally expressed by integrating the growth velocity, defined as the difference between the processes increasing the growth of the examined parameter's value and the processes that decrease it (*1, 2, 3*). Human growth from the fertilised egg to adulthood is a deterministic, self-evolving process performed according to the genetic information contained in the genome created by fusion of the sperm and egg nuclei. Body weight and body length are visible and measurable phenotype manifestations of the genotype.

A growth curve fitted, within the defined probability, into the set of the longitudinal phenotype values of body length (D) or body weight measured (G) yields an objective image of genotype expression dynamics in the body length or body weight phenotype form. From the physiological point of view the experimental body length and body weight values are based on the two contradictory phenomena – anabolism and catabolism (*1*). For example, anabolic processes include accumulation of energy into the molecules of synthesised proteins, fatty acids and glycides (saccharides) retained in the growing body mass (G). Catabolic processes on the contrary represent degradation of saccharides, fatty acids, and proteins incorporated in the body structures. In this way the velocity of anabolic processes is proportional to the body mass increase (dG), the velocity of catabolic processes is proportional to the body weight decrease (- dG). The relation between the anabolic and catabolic processes expressed for example as body weight growth is described by a simple differential equation of the body mass growth velocity $dG/dt = a.G\text{-}b.G^2$. Integrating the differential equation we receive the formula for the calculation of the logistic growth curve $G\ (t) = GLi/(1+c.exp(-a.t))$. The logistic growth curve calculated according to this formula is then fitted within the set of longitudinal data of body mass growth. The same approach is applied to the experimental data of body length growth (D). The integration constant (c) can be calculated from three biological constants, the Dynamic Phenotype parameters of the investigated phenotype trait, using the general form $c = (XLi/X0 - 1)$.

The mathematical coefficient of anabolic processes (a) and the mathematical coefficient of catabolic processes (b) together with the integration constant (c) are, in the Dynamic Phenotype method (*2, 3, 4*), defined by the three parameter values (X0) at the beginning of the growth curve, (XLi) the value of the upper asymptote, and the maximum velocity of the growth in the inflexion point of the growth curve (dXmax). This paper aims to show the utilisation of the Dynamic Phenotype method in evaluating body length, body height, and body weight growth of individual boys in the interval from birth to the age of 18 years. The first point is to demonstrate the application of the Dynamic Phenotype method in fitting the calculated logistic curves to the set of longitudinal growth data belonging to the biological individual. The second point of this presentation is to show that logistic I-, C-, and P-growth curves are uniquely determined by three input constants, the experimental parameter they are able to get the best fit of the calculated logistic curve with the longitudinal growth data of the biological individual collected in the longitudinal experiment. Finally we want to show that the use of the Dynamic Phenotype input parameters of the fitted I-, C-, P- growth curve components can also be used for evaluation of the experimental data presented as "virtual individual's" statistical average of the reference proband group.

MATERIAL AND METHODS

In the longitudinal study of child and adolescent growth carried out in Brno (1961–1982) the length and weight measurements of the body were measured together with a number of socio-economic indices. Measurements were recorded for every individual from birth to 18 years of age. The body length and body weight measurements were performed using the standard method published by *Bouchalová* (*5*). Until the age of one year the measurements took place in three-month intervals, from one year until the age of 18 years the measurements were accomplished in six-month intervals. The data of individual probands are taken from the database of our institute and indexed with family codes. The growth data of body length and body weight from birth to 18 years are fitted with I-,C-,P- components of logistic curves calculated by means of the Dynamic Phenotype method of modelling the growth of mammals published by *Novák* (*3, 4, 6*). The Dynamic Phenotype method allows calculating the logistic curve and the growth velocity curve from three characteristic parameters of the Dynamic Phenotype of the variable measured (Y). In our case the logistic curve fitted through the measured data of weight growth (G) is defined by (G0) – weight at the growth curve starting point, (GLi) – growth curve genetic limit value (upper asymptote), and (dGmax)– maximum velocity of the body weight growth located in the region of the growth curve inflexion point with coordinates (G*, t*). The logistic curve fitted through the body length data measured (D) is defined by (D0) – body length at the starting point of the growth curve, (DLi) – body length genetic limit value (upper asymptote), and (dDmax) – maximum velocity of body length growth curve in the inflexion point with the coordinates (D*, t*).

According to *Karlberg* (*7, 8, 9*), the growth curve of child and adolescent growth is divided into three independent components: (I) – Infancy component, (C) – Childhood component, and (P) – Puberty component. The general input parameters (X0, XLi, and dXmax) of each I-, C-, P- logistic curve component represent a mathematically unique description of the individual genotype expression in the form of its phenotype trait or "channel" according to Prader, Tanner et al. (*11, 12*). The adequate equations used for computation of the body weight growth curves are as follows:

Growth velocity
dG/dt = 4.dGmax. (G/GLi – (G/GLi)2) [kg/time] (1)

Weight growth
G = GLi/(1+(GLi/G0-1). exp (-(4dGmax/GLi).(t-t0))) [kg] (2)

Weight at inflexion point
G* = GLi/2 [kg] (3)

Age when inflexion point is reached
t* = ln(GLi/G0 -1)/(4dGmax/GLi) [time] (4)

For computation of the logistic curve fitted to the data of body length values are in equations (1, 2, 3, 4) the input parameters (D0, DLi and dDmax) used. By means of equation (2) the calculated I-, C-, P- logistic growth curve's components are fitted to the displayed points of experimental data of the body length (D). A similar procedure is applied for the body weight (G). The computation was accomplished in a Microsoft spreadsheet Excel with simultaneous graphic imaging that enables us to control the fitting of the calculated logistic growth curve path by the eye together with computation of the coefficient of determination (r^2). The curves of the corresponding growth velocities calculated according to equation (1) appear in the graph of the evaluated I, C-, P- logistic growth curve components of the assessed individual (*see Fig. 2, Fig. 3*). The coefficient of determination (CD (X)) was estimated as the second power of the correlation coefficient (r^2) between the calculated values of the constructed logistic growth curve, independent variable (X) and values measured in the longitudinal study, the dependent variable (Y). The result is displayed in the appropriate I-, C-, P- segments of data as shown in *Tables 1a and 2a*.

RESULTS

An overview of the body length and body weight data measured in 13 boys enrolled in this presentation is shown in *Fig. 1.* The individual input parameters of the body height DYNAMIC PHENOTYPE (D0, DLi, dDmax) for the fitted I-, C-, P- logistic body height growth curve components of all thirteen probands are presented in *Table 1a*. The input parameters of individual DYNAMIC PHENOTYPES for the fitted I, C, P- logistic growth curve components of body weight for all thirteen probands are presented in *Table 2a*.

Together with the experimental data of individual boys visualised in *Fig. 1* are presented the 3, 50, 97 percentile growth data of average values of body length, body height, and body weight growth of the reference group of boys published by *Bláha et al.* (*10*).

The DYNAMIC PHENOTYPE parameters of the fitted I-,C-,P-logistic percentile body height growth curve calculated from the average values of the reference group of boys published by *Bláha et al.* (*10*) are colligated in *Table 1b*. The Dynamic Phenotypes of the fitted I-, C-, P-logistic body weight growth curve calculated from the average values of the body weight of the reference group of boys published by *Bláha et al.* (*10*) are colligated in *Table 2b*.

For illustration the fitting of I-, C-, P-logistic curve components (heavy lines) of body length and body height growth in a boy with the family code 45 is presented in *Fig. 2.* The fitting of I, C, P-logistic curve components of body weight to the measured longitudinal data of the boy with the family code 45 can be seen in *Fig. 3.* In both figures (*Fig. 2, Fig. 3)* the perpendicular lines delimit the space of I-, C-, P- components of growth curves, small circles mark the values of longitudinal data. The corresponding growth velocity curves are marked as thin lines. The Prader-Tanner “Channels space” (11, 12) is marked by vertical abscissae representing the ± 5 % of the logistic curve value in the appropriate age interval.

Numerical data of the Dynamic Phenotype parameter set estimated for I-, C-, P- logistic curves best fitting the longitudinal experimental data of body length

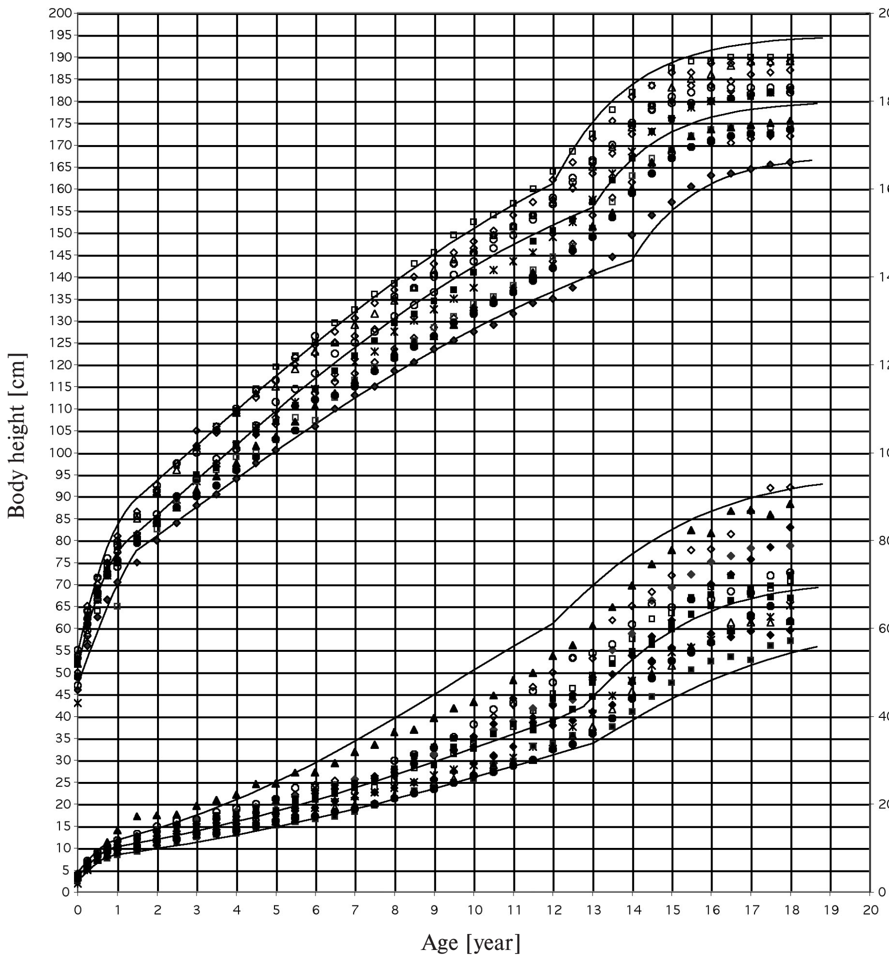

Fig. 1.
Body length growth of boys (top) and body weight growth of boys (bottom) from the birth to the age of 18 years projected on the percentile reference graph of 3 percentile (thin upper line), 50 percentile (heavy line), and 97 percentile (thin line below).
For details see text.

and body height are presented in *Table 1a*. Dynamic Phenotype parameters for calculation of I, C, P-logistic curves best fitting the longitudinal experimental data of body weight in children and adolescents are presented in *Table 2a*.

The parameters of Dynamic Phenotypes in *Tables 1a and 2a* are grouped in three sections named Infancy (I), Childhood (C), and Puberty (P). Each section starts with the age (t0 (x)) at which the corresponding logistic curve begins, followed by data of the Dynamic Phenotype parameters (X0, XLi, dXmax), coefficient of determination (CD (x)) of the fitted logistic curve, to the experimental values of the longitudinal study. The age (t*(x)) at which the inflection point of the corresponding logistic growth curve is reached makes the end of the box.

The interpretation of data in the boy with the family code 45 for body length during the infancy component (I), body height during the childhood component (C), and body height during the puberty component (P) is presented in *Table 1a*.

The I – component of the logistic curve fitted into the experimental data of body length in the boy with the family code 45 is characterised by the following Dynamic Phenotype parameters: natal age t0 (I) = 0 year, body length $D0_{45}$ (I) = 47.0 cm, genetic limit of body length DLi (I) = 84 cm, maximum velocity of growth $dDmax_{45}$ (I) = 45 cm/year. These parameters generate the path of the best-fitted logistic curve, the I-component segment being marked in heavy line (*Fig. 2*).

The C – component of the logistic curve fitted into the experimental data of body height in the boy with the family code 45 is characterised by the following Dynamic Phenotype parameters: age at the beginning of the childhood component t0 (C) = 1.0 year,: $D0_{45}$ (C) = 76.9 cm, genetic limit of body length DLi (C) = 183 cm, $dDmax_{45}$ (C) = 8.2 cm/year. These parameters generate the path of the best-fitted logistic curve, the C - component segment being marked in heavy line (*Fig. 2*).

The P- component of the logistic curve fitted into the experimental data of **body height** in the boy with the family code 45 is characterised by the following Dynamic Phenotype parameters: age at the beginning of the puberty component t0 (P) = 12.0 years, $D0_{45}$ (P) =153.5 cm, genetic limit of body length DLi (P) = 183 cm, $dDmax_{45}$ (P) = 37 cm/year. These parameters generate the path of the best-fitted logistic curve, the P- component segment being marked in heavy line (*Fig. 2*).

The Dynamic Phenotype numerical data of the boy with the family code 45 for body weight from birth up to the age of 18 years (adolescence) are presented in *Table 2a*.

The I- component of the logistic curve fitted into the experimental data of body weight in the boy with the family code 45 is characterised by the following Dynamic

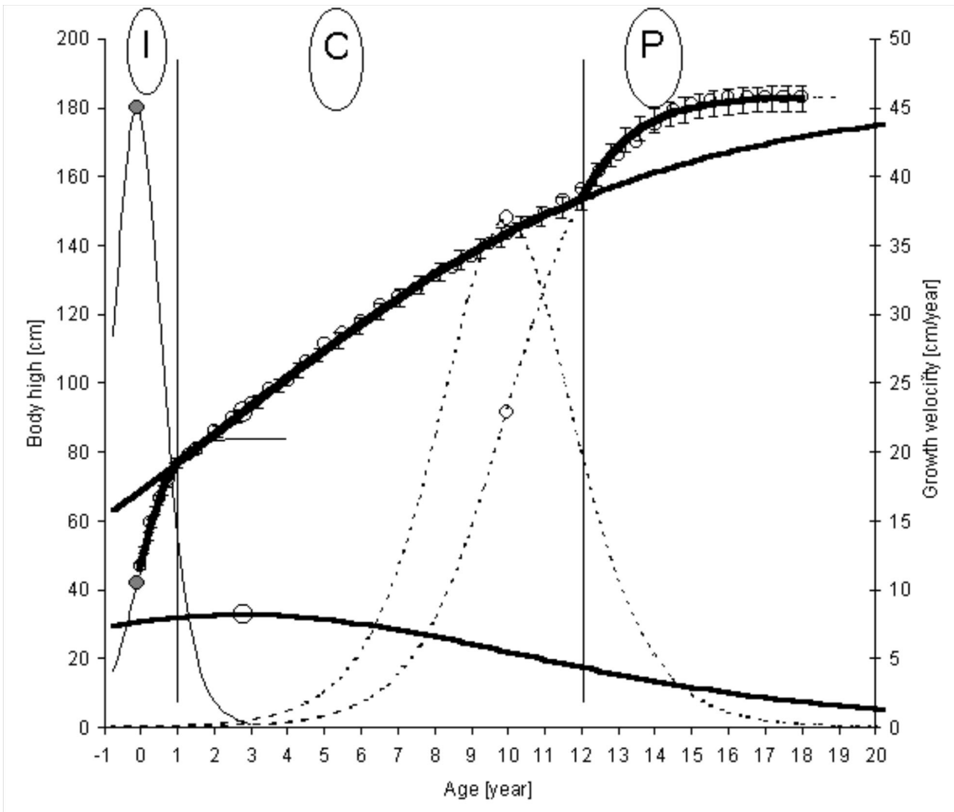

Fig. 2

Body length and body height phenotype trait (heavy line) and the velocity of body length and body height growth (thin lines, dashed lines). The traits are distinguished by vertical lines into three I-, C-, P- components of the growth curve calculated by the Dynamic Phenotype method, i.e. I - infancy component, C – childhood component, P - puberty component. The growth curve trait is fitted to experimental values of the boy with the family code 45. For details see text

Phenotype parameters: natal age t0 (I) = 0 year: birth weight $G0_{45}$ (I) = 2.5 kg, genetic limit of body weight GLi (I) = 10.0 kg, $dGmax_{45}$ (I) = 15.0 kg/year. These parameters generate the path of the best-fitted logistic curve, the I - component segment being marked in heavy line (*Fig. 3*).

The C- component of the logistic curve fitted into the experimental data of body weight in the boy with the family code 45 is characterised by the following Dynamic Phenotype parameters: age at the beginning of the childhood component t0 (C) = 1.0 year: $G0_{45}$ (C) = 9.9 kg, genetic limit of body weight GLi(C) = 70.7 kg, $dGmax_{45}$(C) = 3.6 kg/year. These parameters generate the path of the best-fitted logistic curve, the C - component segment being marked in heavy line (*Fig. 3*).

The P- component of the logistic curve fitted into the experimental data of body **weight** in the boy with the family code 45 is characterised by the following Dynamic Phenotype parameters: age at beginning of the puberty component t0 (P) = 11.0 years: $G0_{45}$ (P) = 36.3 kg, genetic limit of body weight GLi (P) = 70.7 kg, $dGmax_{45}$ (P) = 9.5kg/year. These parameters generate the path of the best-fitted logistic curve, the P-component segment being marked in heavy line (*Fig.3*).

Dynamic Phenotype parameters for each of the thirteen boys included in this study are treated in the manner described above. The numerical values for body length growth are given in *Table 1a.* Dynamic Phenotype parameters of the logistic curve fitted to body weight growth for each of the thirteen boys are ranked in appropriate boxes belonging to the I-, C-, P- growth curve components shown in *Table 2a*. To each boy enrolled in the table belongs a line of data represented by the set of Dynamic Phenotype parameters. The set of Dynamic Phenotype parameters reflects the individuality of genotype expression in body length and body weight growth of the boy with the marked family code. Tabulated critical values of correlation coefficient are at the level $P_{0,01}$=0,874 for ν=5. The CD (X) values of determination coefficient in the particular I-, C-, P- sections in *Tables 1a and 2a*, the smallest ν=10 and all values of the determination coefficient are much higher. This indicates a tight relation between the constructed component of the fitted logistic curve section and the corresponding experimental values. A similar tight relation, with very high values of the determination coefficient CD (X), can also be seen between the constructed components of the fitted logistic curve to the body height and body weight average values of the reference groups of boys expressed in the form of the percentile growth data (see *Fig. 1*, *Tables 1b* and *2b*). In this case the significance is not marked in *Tables 1b* and *2b* because the lowest r^2 = 0.943. The table value $P_{0.01}$ = 0.874 for the smallest ν=5.

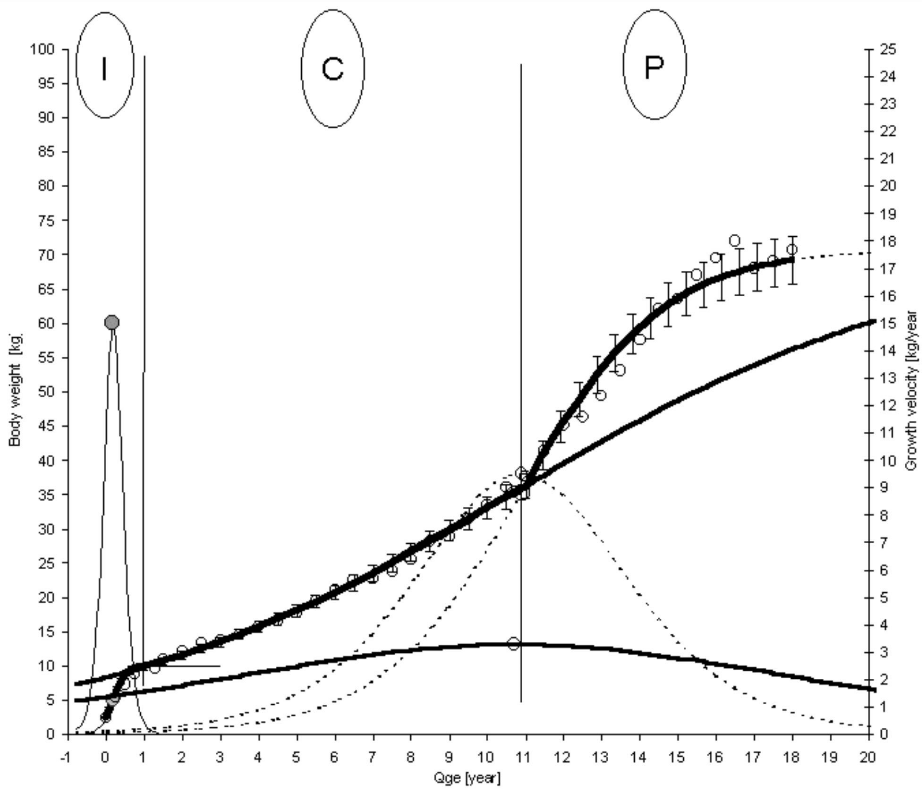

Fig. 3

Body mass growth phenotype trait (heavy line) and the velocity of body mass growth (thin lines, dashed lines). The traits are distinguished by vertical lines into three I-, C-, P- components of the growth curve calculated by the Dynamic Phenotype method, i.e. I – infancy component, C – childhood component, P - puberty component. For details see text

DISCUSSION

The main objective of this presentation is to demonstrate that each component of the constructed growth curve of boys (estimated from the longitudinal data of body length (D), body height (D), and body weight measured (G) in the interval from birth to the age of 18 years) represents the path of the best-fitted logistic curve, and the I, C, P-component segments are marked as heavy lines (see *Figs. 2 3*). The growth principle taking into account anabolic and catabolic processes defined by the simple differential equation (1) can derive each of the logistic curves mathematically by three general constants (X0 – value of variable at the beginning of the fitted logistic curve, XLi – upper asymptote of the logistic curve, dXmax – maximal growth velocity reached). The estimated constants (X0, XLi, dXmax) are parameters of the Dynamic Phenotype that uniquely determine the whole trait of the logistic curve. The numerical values of Dynamic Phenotype parameters are set during the procedure of fitting the logistic curve as variable (X) to the measured values of variable (Y). All three parameters of the Dynamic Phenotype can be read as soon as the logistic curve has reached the best fit with the experimental data. This moment can be controlled "by the eye", together with the computation of the determination coefficient CD (X) or using the Microsoft "Solver procedure", or some other procedures that the author himself is capable of programming .

It is interesting to observe that the longitudinal data of body weight growth velocity in a biological individual (a boy with family code 45) in the C- curve component, in comparison with the growth velocity of the P- curve component, are markedly different in the position of the velocity peak, dGmax(C) = 3.3 kg/year, dGmax (P) = 9.5 kg/year. However, the peaks of both growth velocity curves are reached at almost an identical age t*(C)= 10.71 years, t*(P) = 10.90 years (10 years, 10 months). It is noteworthy that at this age also the pubertal spurt starts. However, this phenomenon is not observed in the timing of body height velocities, t*(C) 2.8 years (2 years and 9 months), t*(P)=9.96 years, and the observable individual pubertal spurt of the body height in longitudinal values starts until the age t_x=12 years! The reason for this difference is doubtless conditioned by timing and differences in hormonal regulation of the growth of body length and body weight.

The input Dynamic Phenotype parameters of the I-, C-, P- growth curve components estimated separately for the body length and body height of all boys are summarised in *Table 1a* and for body weight in *Table 2a*. The data presented demonstrate the validity of fitting the logistic curves calculated by the Dynamic Phenotype method to longitudinal growth data and confirm that the logistic I-, C-, P-components of the growth curves investigated are uniquely determined by three input parameters representing the biological character of the investigated variables. All at once it was shown that the use of the Dynamic Phenotype's input parameters of the fitted I-, C-, P- curve components is compatible with the reference percentile graph method commonly applied to the assessment of differences observed in the growth of individual children and adolescents evaluated (*Tables 1b, 2b*).

The (I), (C), and (P) components of the growth curves are for every individual expressed by the Dynamic Phenotype parameters which are shown in *Tables 1a and 2a*. The particular body height or body weight values may sometimes deviate from the fitted growth curve course. Such deviations indicate a possible influence of changes in the inner or outer environment linked to disorders in nutrition, physical or psychological stress, diseases, or, as the case may be, by the presence of harmful substances, as was confirmed in various studies (*10, 11, 12*). The Dynamic Phenotype method used allows an exact time description of individual human growth curve components. However, the same approach can also be applied to the percentile for body length growth in *Tables 1a and 1b*, and for body weight growth in *Tables 2a and 2b*.

The Dynamic Phenotype parameters have a direct relation to mathematical constants (X0, XLi, dXmax) of the logistic curve and allow quantitative description of the causes; they can be joined with the observed differences between the trait of the logistic curve and the actual experimental values measured. For instance, changes in the growth rate induced by therapy procedures and the following return to the norm were joined according to the "channelling principle" of the growth curve (11, 12) by changes introduced by the lifestyle modification (*13*). The logistic curve offers a more accurate growth course evaluation than do the percentile graphs, as noted by *Marubini* (*14*). Dynamic Phenotype parameters are a precise mathematical expression for the logistic growth curve, which fits better the individual values of the longitudinal measurements than the averaged values of the percentile graph. Therefore, the individual logistic curve trajectory divided into three growth curve components better describes genotype expression in its phenotype form and may better reflect the influence of inner and outer environmental conditions. The Dynamic Phenotype method allows the solution of logistic curve fitting even in cases when the growth data collected are available in irregular intervals.

CONCLUSION

We consider this article as a methodical pilot programme focused on recognition of individual differences in the dimensions of body length and body weight growth of the human body based on the parents' phenotypic markers.

The Dynamic Phenotype method provides a more precise mathematical description of the individual's dynamic genotype expression in the selected phenotype markers (body length growth, body height growth, body weight growth) than the current statistical methods dealing with averaged values of a "virtual individual". This approach may be a prospective way to the correlation of various phenotype traits with the information on the molecular structures of chromosomes

Table 1a

Parameters of Dynamic Phenotype for body leght in boys of the Brno longitudinal study aranged according dDmax (C)

	INFANCY (I)						CHILDHOOD (C)						PUBERTY (P)						ICP
Family code	Age [year]	Birth body length [cm]	Genetic body length limit [cm]	Maximum growth velocity [cm/year]	Determination coeficient	Age at inflexion [year]	Age [year]	Initial body heigh [cm]	Genetic limit of body heigth [cm]	Maximum growth velocity [cm/year]	Determination coeficient	Age at inflexion [year]	Age [year]	Initial body heigh [cm]	Genetic limit of body heigth [cm]	Maximum growth velocity [cm/year]	Determination coeficient	Age at inflexion [year]	Determination coefficient
		D0 (I)	DLi (I)	dDmax (I)	CD (I)	t* (I)		D0 (C)	DLi (C)	dDmax (C)	CD (C)	t* (C)		D0 (P)	DLi (P)	dDmax (P)	CD (P)	t* (P)	ICP
349	0,0	54,0	80,0	56,0	0,979	-0,261	1,0	77,7	173,0	7,1	0,995	2,240	12,5	145,9	173,0	35,0	0,989	10,42	0,998
495	0,0	49,0	75,0	55,0	0,999	-0,216	1,0	72,9	173,5	7,5	0,998	2,857	13,0	147,9	173,5	38,0	0,995	11,00	0,995
147	0,0	52,0	75,0	55,0	0,997	-0,278	1,0	73,3	175,5	7,5	0,999	2,948	13,0	148,8	175,5	38,0	0,996	11,02	0,995
533	0,0	46,0	72,0	40,0	0,998	-0,257	1,0	67,8	168,0	7,6	0,995	3,153	13,5	145,6	168,0	24,0	0,997	10,22	0,993
57	0,0	47,0	85,0	45,0	0,983	-0,100	1,0	77,5	183,0	8,0	0,998	2,768	11,0	147,9	183,0	45,0	0,992	9,537	0,995
477	0,0	53,0	80,0	45,0	0,999	-0,300	1,0	75,9	182,5	8,0	0,998	2,934	13,0	155,8	182,5	38,0	0,994	10,88	0,995
423	0,0	49,0	72,0	75,0	0,979	-0,182	0,8	70,5	175,0	8,0	0,988	2,896	14,0	154,7	175,0	30,0	0,997	11,04	0,987
517	0,0	43,0	78,0	55,0	0,998	-0,073	1,0	74,4	182,5	8,3	0,998	3,055	12,5	154,7	182,5	30,0	0,997	9,887	0,995
449	0,0	54,0	85,0	45,0	0,974	-0,262	1,0	79,5	189,0	8,5	0,996	2,779	13,0	163,1	189,0	35,0	0,994	10,52	0,995
45	0,0	53,0	85,0	45,0	0,992	-0,238	1,5	82,9	187,0	9,0	0,995	2,682	13,0	164,4	187,0	35,0	0,992	10,35	0,995
489	0,0	55,0	85,0	45,0	0,999	-0,286	1,0	79,8	182,0	9,0	0,995	2,255	12,5	160,8	182,0	45,0	0,982	10,45	0,995
377	0,0	52,0	85,0	45,0	0,952	-0,215	1,0	79,0	190,0	9,3	0,998	2,740	12,5	165,5	190,0	42,0	0,978	10,34	0,995
55	0,0	50,0	85,0	45,0	0,997	-0,168	1,0	78,4	189,0	9,3	0,996	2,749	12,5	164,8	189,0	45,0	0,991	10,48	0,995
Average	0,00	50,5	80,2	50,1	0,988	-0,218	1,0	76,1	180,8	8,2	0,996	2,773	2,773	155,4	180,8	36,9	0,992	10,472	0,995
± SD	0,00	3,60	5,26	9,18	0,01	0,07	0,16	4,18	7,13	0,73	0,003	0,268	0,268	7,65	7,13	6,45	0,01	0,445	0,003
Cv %		7,12	6,56	18,33	1,44	-32,23	15,71	5,49	3,94	8,90	0,29	9,68	9,68	4,93	3,94	17,46	0,60	4,25	0,25
N	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13

Table 1b

Dynamic Phenotype entering parameters for body length of percentile data published by Bláha Vignerová et al, 2001

Component	INFANCY (I)					CHILDHOOD (C)	PUBERTY (P)								
Codes of the variable / family	Age [year]	Birth length [cm]	Genetic limited body length [cm]	Maximum growth velocity [cm/year]	Age of Inflexion [year]	Age [year]	Stature at origin [cm]	Genetic limited posture [cm]	Maximum growth velocity [cm/year]	Age of Inflexion [year]	Age [year]	Posture at origin [cm]	Genetic limited posture [cm]	Maximum growth velocity [cm/year]	Age of Inflexion [year]
	Age	D0 (I)	DLi (I)	dDmax (I)	t* (I)	Age	D0 (C)	DLi (C)	dDmax (C)	t* (C)	Age	D0 (P)	DLi (P)	dDmax (P)	t* (P)
3. PERC BLÁHA	0,0	47,0	93,0	25,0	-0,02	1,50	77,8	167,5	6,5	2,41	14,0	143,7	167,5	30,0	11,49
50. PERC BLÁHA	0,0	51,0	85,0	40,0	-0,22	1,50	81,8	180,0	8,0	2,53	13,0	155,8	180,0	30,0	10,21
97. PERC BLÁHA	0,0	54,3	95,0	40,0	-0,17	1,50	89,6	195,0	8,0	2,49	12,0	161,2	195,0	30,0	9,46
AVERAGE		50,8	91,0	35,0	-0,14	1,5	83,1	180,8	7,5	2,5	13,0	153,6	180,8	30,0	10,4
± SD		3,7	5,3	8,7	0,10	0,0	6,0	13,8	0,9	0,1	1,0	8,9	13,8	0,0	1,0
CV%		7,2	5,8	24,7	-75,6	0,0	7,2	7,6	11,5	2,4	7,7	5,8	7,6	0,0	9,9
N		3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0

Table 2a

Parameters of Dynamic Phenotype for body weight in boys of the Brno longitudinal study arranged according dGmax (C)

	INFANCY (I)						CHILDHOOD (C)						PUBERTY (P)						ICP
Family code	Age [year]	Birth body weight [kg]	Genetic body weight limit [kg]	Maximum body weight growth velocity [kg/year]	Determination coeficient	Age at inflexion point [year]	Age [year]	Initial body weight [kg]	Genetic body weight limit [kg]	Maximum body weight growth velocity [kg/year]	Determination coeficient	Age at inflexion point [year]	Age [year]	Initial body weight [kg]	Genetic body weight limit [kg]	Maximum body weight growth velocity [kg/year]	Determination coeficient	Age at inflexion point [year]	Koeficient determinace
	t (I)	G0 (I)	GLi (I)	dGmax (I)	CD (I)	t* (I)	t (C)	G0 (C)	GLi (C)	dGmax (C)	CD (C)	t* (C)	t (P)	G0 (P)	GLi (P)	dGmax (P)	Comp (P)	t* (P)	CD (ICP)
377	0,0	2,5	9,0	8,3	0,978	0,259	1,5	8,9	50,0	1,9	0,996	11,56	12,5	26,8	50,0	6,0	0,975	12,20	0,996
533	0,0	3,0	10,0	12,0	0,993	0,177	1,0	9,8	65,0	2,4	0,995	12,69	13,0	33,2	65,0	11,0	0,993	12,93	0,998
57	0,0	3,8	11,0	8,7	0,985	0,202	1,0	10,2	60,0	2,5	0,995	10,52	9,5	27,4	60,0	5,5	0,955	9,966	0,987
517	0,0	3,4	9,0	9,0	0,989	0,125	1,0	8,7	61,7	2,7	0,994	11,30	12,5	34,1	61,7	9,0	0,993	12,14	0,996
55	0,0	1,9	10,0	12,0	0,986	0,302	1,0	9,7	65,0	2,8	0,995	11,13	12,5	36,3	65,0	10,5	0,992	12,13	0,998
349	0,0	2,7	9,0	8,5	0,982	0,224	0,8	7,9	58,0	2,8	0,979	10,31	13,5	37,7	58,0	9,0	0,984	12,51	0,992
489	0,0	3,8	11,0	11,0	0,999	0,160	1,0	10,6	72,1	3,2	0,984	10,88	12,5	41,2	72,1	10,0	0,995	11,98	0,998
45	0,0	2,5	10,0	11,0	0,992	0,250	1,0	9,6	71,0	3,5	0,995	10,38	10,0	34,2	71,0	7,4	0,965	10,18	0,990
477	0,0	3,9	12,0	11,0	0,979	0,199	1,0	11,4	72,7	3,5	0,995	9,74	10,0	37,3	72,7	6,5	0,983	9,859	0,996
423	0,0	3,3	10,0	11,0	0,996	0,161	1,0	9,8	66,9	3,6	0,992	9,21	12,0	43,2	66,9	7,0	0,984	10,57	0,990
495	0,0	3,6	11,0	11,0	0,980	0,180	1,0	10,6	83,0	3,8	0,992	11,49	13,5	49,1	83,0	9,5	0,988	12,70	0,995
449	0,0	4,1	15,0	11,0	0,950	0,333	1,0	13,1	88,3	4,3	0,995	9,95	12,0	52,8	88,3	10,5	0,993	11,16	0,996
147	0,0	3,5	10,0	11,0	0,995	0,141	1,0	9,8	92,1	4,5	0,973	11,90	10,5	39,8	92,1	7,5	0,980	11,34	0,988
Průměr	0,0	3,2	10,5	10,4	0,985	0,209	1,0	10,0	69,7	3,2	0,991	10,852	11,8	37,9	69,7	8,4	0,983	11,513	0,994
± SD		0,66	1,61	1,31	0,01	0,06	0,16	1,30	12,17	0,76	0,007	0,959	1,38	7,51	12,17	1,86	0,01	1,07	0,004
CV %		20,51	15,31	12,54	1,28	30,01	15,71	12,93	17,46	23,91	0,73	8,84	11,61	19,79	17,46	22,13	1,22	9,32	0,39
N	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13

Table 2b

Dynamic Phenotype entering parameters for body weigth of percentile data published by *Bláha Vignerová et al,* 2001

Component	INFANCY (I)					CHILDHOOD (C)					PUBERTY (P)				
Codes of the variable / family	Age [year]	Birth weight [kg]	Genetic limited weight [kg]	Maximum body weight growth velocity [kg/year]	Age of Inflexion [year]	Age [year]	Weight at origin [kg]	Genetic limited weight [kg]	Maximum body weight growth velocity [kg/year]	Age of Inflexion [year]	Age [year]	Weight at origin [kg]	Genetic limited weight [kg]	Maximum body weight growth velocity [kg/year]	Age of Inflexion [year]
	Age	G0 (I)	Gli (I)	dGmax (I)	t* (I)	Age	G0 (C)	GLi (C)	dGmax (C)	t* (C)	Age	G0 (P)	Gli (P)	dGmax (P)	t* (P)
3. Perc Bláha	0,0	2,7	9,0	8,5	0,22	1,00	8,5	62,0	2,6	11,93	13,0	33,8	62,0	7,0	12,60
50. Perc Bláha	0,0	3,5	10,8	10,0	0,20	1,00	10,3	71,0	3,2	10,01	12,8	42,4	71,0	10,0	11,30
97. Perc Bláha	0,0	4,4	12,5	11,0	0,18	1,00	11,8	96,0	5,5	9,56	12,0	61,1	96,0	10,0	10,66
Average		3,5	10,8	9,8	0,20	1,0	10,2	76,3	3,8	10,5	12,6	45,7	76,3	9,0	11,5
± SD		0,8	1,8	1,3	0,02	0,0	1,7	17,6	1,5	1,3	0,5	14,0	17,6	1,7	1,0
Cv%		23,6	16,3	12,8	11,7	0,0	16,2	23,1	40,6	12,0	4,2	30,5	23,1	19,2	8,6
n		3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0

and their relations, as postulated in Barker's hypothesis (*15*) on the origin of heart diseases.

The presented results of the Dynamic Phenotype method in evaluating the growth process of children and adolescents provide a large scale of accurate mathematically defined information about the dynamics of the growth process. This data derived from mathematical relations between the fitted growth curve and the derived velocities of growth processes can markedly contribute to future studies dealing with the lifestyle and its relations to environmental conditions, the level of various stressors, the state of nutrition on one side and the regulatory role of neural and humoral mechanisms on the other.

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