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PERCENTILES OF THE HUMAN GROWTH VELOCITY, BASED ON THE "BUDAPEST LONGITUDINAL GROWTH STUDY"

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Abstract: *In the "Budapest Longitudinal Growth Study" about four thousand children were investigated annually from 1970 (their year of birth) to 1988. Among various measurements several anthropometrical ones has been taken. We have chosen the 665 males and 739 females who had complete records of height to determine their growth velocities. First we fitted individual growth curves. The best fit could be achieved by the method of Bock and Thissen (triple logistic). Velocity curves has been determined by calculation of the derivatives of the growth curves at preassigned time points.*

The median growth velocity of boys reached its maximum of 7.5 cm/year at their age of 13, the minimum preceeding if being 4.8 (10). The same number of girls were 6.8 (11) and 5.2 (9), respectively (ages in brackets). Higher percentiles (90, 97) showed considerably greater differences between the maximum and preceeding minimum, lower ones (3, 10) showed much less difference, or didn't have any peak at all.

Key words: *Growth velocity; Budapest Longitudinal Growth Study.*

There are several advantages of investigating the same cohort longitudinally, as compared to cross-sectional studies. One of them is that not only can the general tendency of growth be described, which can also be seen using cross-sectional data, but its inter-individual variability as well. This can be shown by constructing percentile curves of the growth velocities.

The data were taken from a longitudinal study, in the course of which children from Budapest were investigated annually from 1970 (their year of birth) to 1988. We have chosen the 665 males and 739 females who had complete records of height to determine their growth velocities.

This can be done in various ways. We have chosen to fit individual growth curves for three reasons. First, for technical reasons: the measurements of all individuals were taken each year during a period of a couple of weeks period, therefore, they were not measured at exactly the same age. This inevitably called for some kind of correction for age, which could easily be done in this way. Secondly, by fitting curves measurement errors and short-term variability could be smoothed out. Finally, perecentiles calculated from the fitted function doesn't need further smoothing.

Two models have been fitted to the data, the nine parameter model suggested by Bock and Thissen (1980) which is in fact the sum of three logistic functions:

$$y = a_1 \left[\frac{1-p}{1+e^{-b_1 (t-c_1)}} + \frac{p}{1+e^{-b_2 (t-c_2)}} \right] + \frac{a_2}{1+e^{-b_3 (t-c_3)}} ;$$

and a seven parameter model recently developed by Jolicouer et al. (1988):

$$y = A \left\{ 1 - \frac{1}{1+ (t/D_1)^{c_1} + (t/D_2)^{c_2} + (t/D_3)^{c_3}} \right\}$$

where y = height, t = age.

There are several other models used in modelling human growth, however, they have been only used in shorter periods, either in infancy and childhood or adolescence. The first model proved to be superior to the other one: it showed lower average residual mean square, therefore, it has been chosen for further calculations (Hauspie 1989).

Velocity values have been determined by calculating the derivatives of the growth curves at preassigned time points. At every timepoint the 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles have been determined.

The velocity curves of the boys from their birth to their age of 19 are presented in *Fig. 1*. The median curve is marked by dots. In the first six months the median (over 25 cm/year) as well as the variability are fairly high, both showing a very fast decrease afterwards. In order to render an easier differentiation of the curves, on *Fig. 2* one can see them in the period of 1 to 19 years. On the left the inpact of a small pre-pubertal spurt is expressed in a stagnation of velocities after the steep decrease. The median growth velocity reaches its maximum of 7.5 cm/year at the age of 13.5 years the minimum preceeding it being 4.8 cm/years at the age of 10.5 years. The median at 19 years is 0.6 cm/year and the upper percentiles are still rather far from zero. Higher percentiles show considerably greater differences between the maximum and preceeding minimum then the median, the lower ones, on the contrary, have only a minimal rise in this period. That means, the variability is caused mainly by the significant phase shift in the adolescent growth.

The next two figures present the percentile charts for females. The shapes of curves are similar to those of ones on the preceeding figures. The prepubertal minimum of the median is 5.2 cm/year at the age of 9 years, and a maximum of 6.8 cm/year is at 11 years. At the age of 19 even the higher percentiles are close to the zero, the median being 0.2 cm/year (*Fig. 3* and *4*.).

In order to compare the velocity curves of the boys and girls, on *Fig. 5* the medians as well as the 10th and 90th percentiles of both sexes are shown. Beside the well known adolescent phase difference between the sexes, another systematic difference between the curves can be observed: in early childhood those of females remain higher, then, descending more rapidly, the curves of the two sexes intersect at about six years.

It is well known, that, though the median at a time-point is a value characteristic of the velocities measured at the age, the median curve cannot be considered as a typical growth curve. Because of the phase difference between individuals in adolescent growth it is considerably flatter, with lower maximal velocity at puberty, than individual curves. The median-constant curve having as parameters the medians of those of individual curves has the advantageous property of being a "typical" one. On *Fig. 6* both the median curve and the median-constant curve of the boys are shown. Although the latter has more pronaunced turns, there is only a slight difference, except for the adolescent period. The difference between maximal adolescent velocities is as much as 2 cm/year. The time of maximal velocity is, however, practically unchanged.

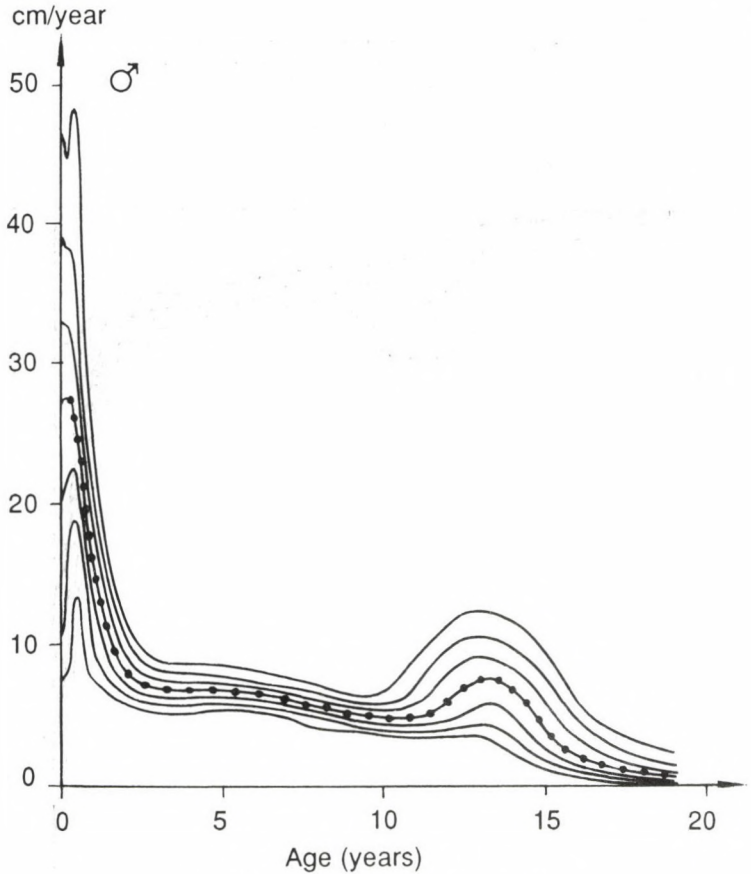

Fig. 1: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (males, 0 to 19 years; 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles)

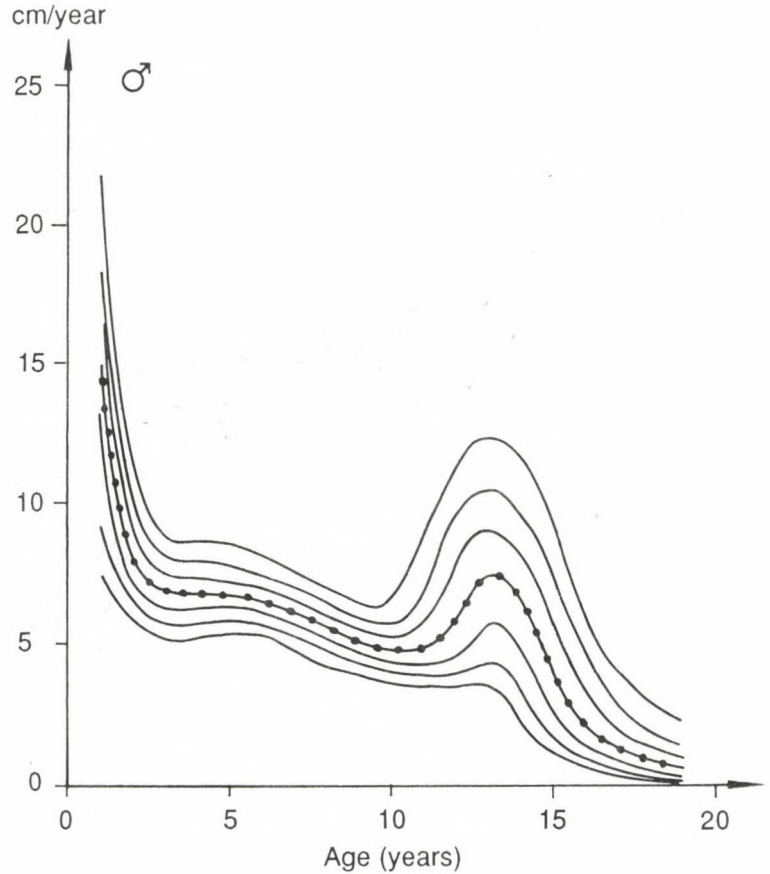

Fig. 2: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (males, 1 to 19 years; 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles)

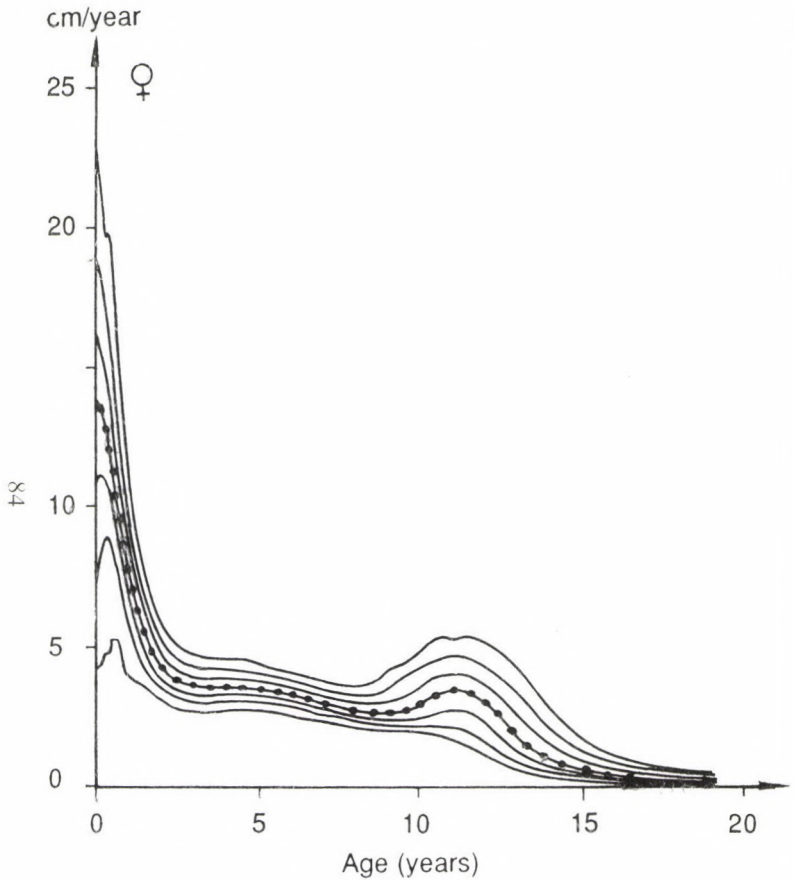

Fig. 3: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (females, 0 to 19 years; 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles)

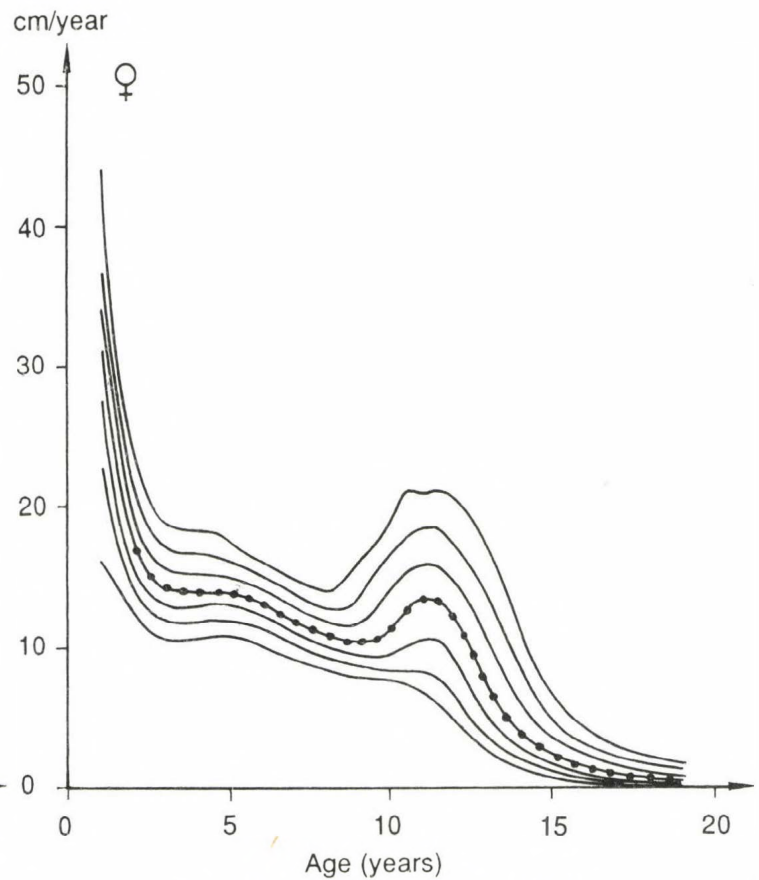

Fig. 4: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (females, 1 to 19 years; 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles)

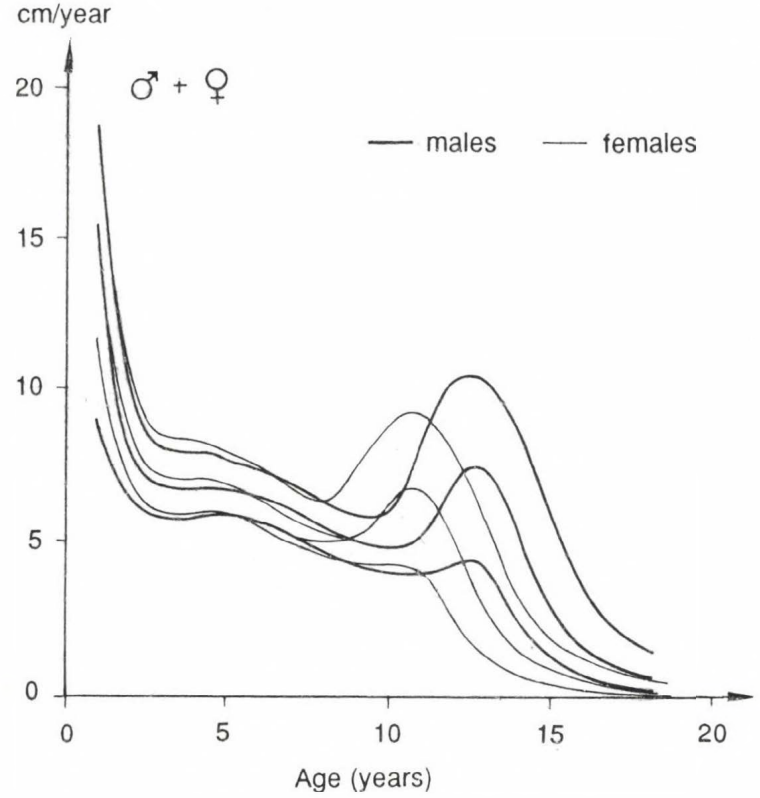

Fig. 5: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (males and females, 1 to 19 years; 10th, 50th, and 90th, percentiles)

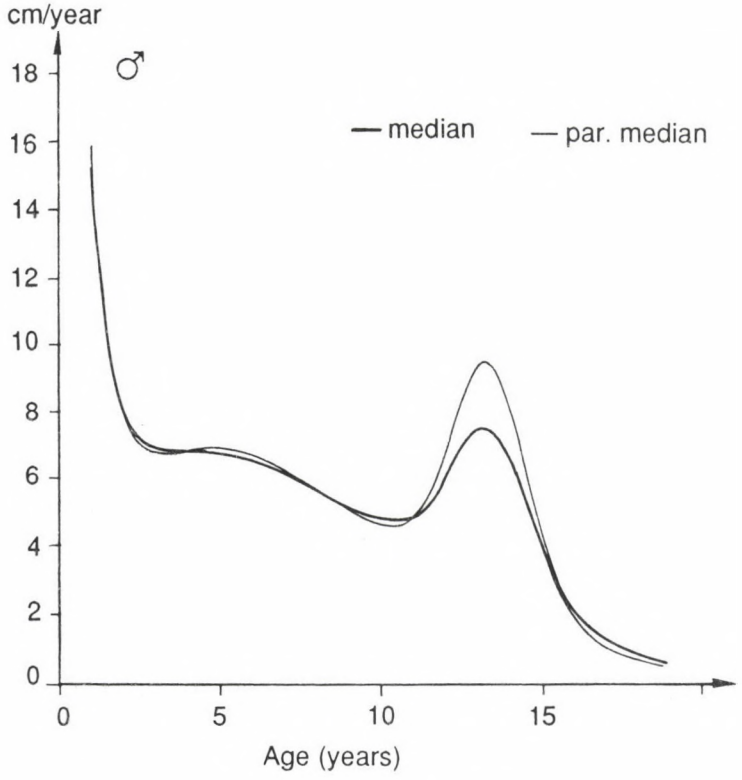

Fig. 6: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (males, 1 to 19 years; median and par. median curves)

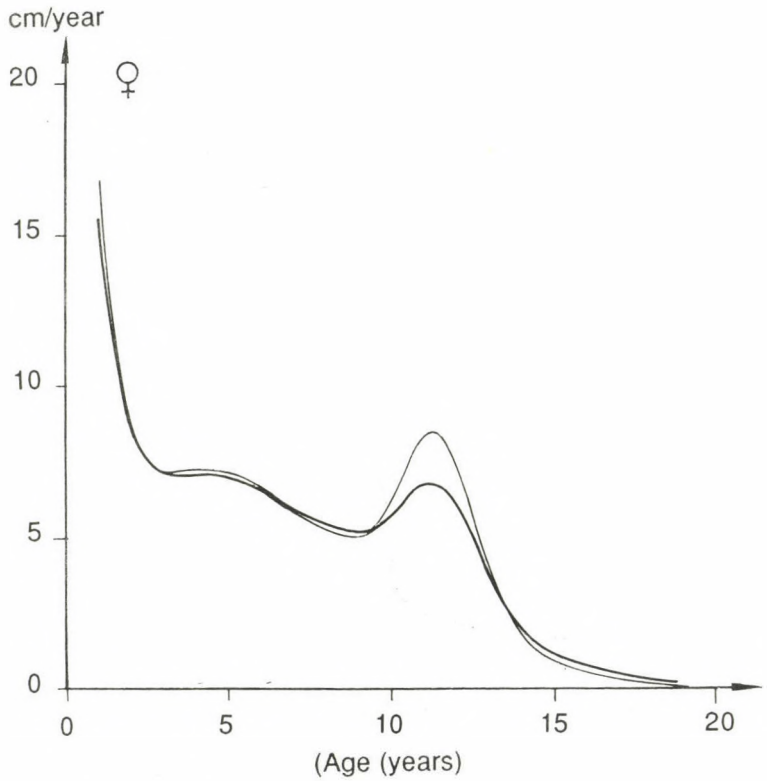

Fig. 7: Percentile curves of growth velocity, based on the Budapest Longitudinal Growth Study (females, 1 to 19 years; median and par. median curves)

The same can be said as far as the girls are concerned (*Fig. 7*).

In conclusion: Percentile curves of growth velocities seem to provide a better insight into the growing process.

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