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EARLY AND LATE MATURERS

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Abstract: Individual growth curves of six boys and six girls with the earliest and of six boys and six girls with the latest onset of physical maturation from a group of 300 Prague children followed up longitudinally from birth to maturity, were analysed and the intergroup and intersexual differences were compared. There was a 6 year difference in the peak velocity heights between the most early and most lately maturing boys, 5 year difference between the girls and nearly 8 year difference between the most early maturing girl and most lately maturing boy. A difference of 14 cm was found in boys and 18 in girls between the means of height of early and late maturers at the age of peak velocity height.

From the point of view of psychology (M. Havlínová) the late maturing boys tend to be socially more reserved and more frequently serious in contrast to early maturers. This finding has not been confirmed in the girls. School achievements were slightly better in the late than in the early maturing groups, in agreement with the generally known fact, that school progress is temporarily changing for worse during the puberty period.

Key words: early and late maturer children, peak height velocity (PHV), High School Personality Test (HSPT), longitudinal growth study, Prague children.

Introduction

Two examples may illustrate the point that the problem of the growth of children and youth is essentially a biological process, like in all other living organisms and that in human beings it is simultaneously a highly social matter. This year an exhibition was held in Prague of bonsai, i.e. fully developed trees 20—30 years old which, however, due to special cultivation, reach a height of 20 to 25 cm. From the activities of the bonsai growers (practised in Japan for centuries), we get a good idea of what harms or inhibits growth of the organism (at least for a number of trees grown in miniature form) and from this again we can draw the conclusion what benefits the organism — fundamentally it is just the opposite from what retards growth. The bonsai growers nip off leaves, sprouts and fruits, cut the roots, do not expose the trees much to heat, light and the sun and plant them into poor soil. Analogical to the leaves of plants are human lungs, and to roots the digestive organs or rather nutrition generally. So much only, for demonstrating the biological essence of growth (Fig. 1).

An example of the importance of human society for healthy development is provided by two Indian girls which from babyhood grew up without human company under the care of a she-wolf in the jungle, and whose story was

Fig. 1. Bonsai — a grown up tree of miniature size as a result of special treatment oppressing growth

published in the journal L'Anthropologie. The girls were seven and nine year-old, respectively, when they were found. They moved around on their knees on which they had large callosities, and ran on all fours. They imitated wolves also by not using their hands when eating. Under clinical care lasting several years one of the girls did not learn more than 45 words. Their return to human society was no more possible. Man has evolved as a species during his phylogenetic development and during his ontogenetic evolution he again develops into human only under conditions prepared for him by the family and human society.

The problem of early and late maturers has attracted the attention of many authors. Several of them summarised the present knowledge of factors, influencing the velocity of physical maturation and the biological age in the second decade of life (Tanner 1962, Marshall 1977, Wieringen et al. 1971, Hauspie 1980 and others). Nevertheless, neither an early start nor a late onset of puberty and/or its duration has been satisfactorily explained. This makes any sort of prediction at this age difficult and inaccurate. Last but not least an extreme deviation from the normal in this or that respect implies a social problem. In case of late maturers an unpleasant impact may be exerted on personality development, especially in boys.

In 1981 we brought to a close a longitudinal study of 300 Prague children, lasting for 25 years, followed-up from birth to maturity, which gives us the possibility to participate in solving the still open problem of early and late maturing boys and girls (Kapalín et al. 1969, Prokopec et al. 1981).

Material and Methods

We have analysed both distance and velocity curves of 89 byos and of 89 girls followed-up longitudinally from birth to maturity. The 300 children had been selected at random from a part of Prague (Žižkov) with about 100,000

inhabitants in 1956—1960. Only children born on one particular day in the week (Wednesday) were included into the sample. The children were investigated by a team of specialists clinically, anthropologically and psychologically five times in their first year of life and semiannually thereafter. The original number decreased until 1981 by about one third. Out of twenty measurements taken at each visit and from a series of descriptive features only body height (growth curves), menarcheal age, somatotype, school achievement, eye colour, social background, Cattell's High School Personality Questionnaire and pro-

Table 1

Parameters of growth curves of Prague children and adolescents

No. Symbol	Parameter	Boys n = 89		Girls n = 89	
		$\bar{x}$ / s	min. / max.	$\bar{x}$ / s	min. / max.
1. AMHV	age at minimal prepubertal height velocity (yr)	10.6 / 1.0	7.6 / 14.2	8.9 / 1.1	6.4 / 12.1
2. APHV	age at peak height velocity (yr)	13.5 / 1.0	11.3 / 17.0	11.4 / 1.1	9.1 / 13.6
3. AMHVR	age at minimal prepubertal height velocity return (yr)	15.1 / 1.0	13.1 / 18.7	12.8 / 1.1	10.4 / 15.3
4. H 4	height at age 4 (cm)	105.0 / 4.0	97.1 / 126.2	103.9 / 3.3	97.6 / 111.9
5. HMHV	height at minimal prepubertal height velocity (cm)	143.6 / 7.4	126.2 / 162.3	134.2 / 7.3	119.3 / 159.7
6. TAG	total adolescent gain (cm)	30.7 / 4.8	15.9 / 42.1	25.6 / 5.0	11.9 / 38.3
7. HPHV	height at peak height velocity (cm)	162.2 / 6.5	145.0 / 177.2	150.0 / 6.4	135.1 / 170.2
8. HMHVR	height at minimal prepubertal height velocity return (cm)	174.2 / 6.0	160.3 / 187.8	159.7 / 6.1	143.1 / 178.5
9. HA	adult height (cm)	178.9 / 6.1	164.9 / 192.1	167.1 / 5.8	155.3 / 186.6
10. V 5	height velocity at age 5 (cm/year)	6.7 / 0.8	4.8 / 8.3	6.8 / 0.9	3.5 / 8.9
11. MHV	minimal prepubertal height velocity (cm/year)	4.6 / 0.7	3.2 / 6.6	5.2 / 0.7	3.1 / 7.2
12. PHV	peak height velocity (cm/yr)	8.6 / 1.1	6.1 / 11.8	7.5 / 0.9	5.5 / 9.6
13. PH	peak height (cm/yr)	4.0 / 1.2	0.9 / 8.5	2.3 / 1.0	0.5 / 5.5
14. PB	peak basis (yr)	4.6 / 0.7	2.5 / 6.2	4.0 / 0.7	2.2 / 5.9
15. PAR	peak area = PH × PB	18.5 / 6.7	2.2 / 45.2	9.3 / 4.9	1.1 / 26.7

fessional orientation were used. Incomplete records were not involved in the present study.

The individual growth curves (distance curves) were evened out and some missing observations were incorporated by the method described by CLINE (1974) — a third grade polynomial using 7 points (arguments), which are shifted. This procedure had been used twice on the distance curve, from which yearly increments were derived and used for construction of velocity curve. The velocity curve has been also smoothed by the same polynomial of third grade (seven points), which may be applied not only to concave and convex parts of a curve but also to S-shape sections. Fifteen parameters have been recorded from each velocity curve following the method and nomenclature described by STÜTZLE et al. (1976). Each individual velocity curve has been described by parameters shown in Table 1. Items No 1—3 concern age, 4—9 height, 10—12 velocity and 13—15 characterize the size of the proper peak.

Results

Results are given in Tables and Figures. Fig. 2 shows an individual distance (above) and a velocity curve (below) with some of the parameters derived from its course (minimum growth increment before puberty, peak height velocity, total pubertal gain etc.) Data in Table 1 show average parameters, standard deviations and minimal and maximal values of the parameters of the velocity curves of 89 boys and 89 girls. Similar values reveal mean height

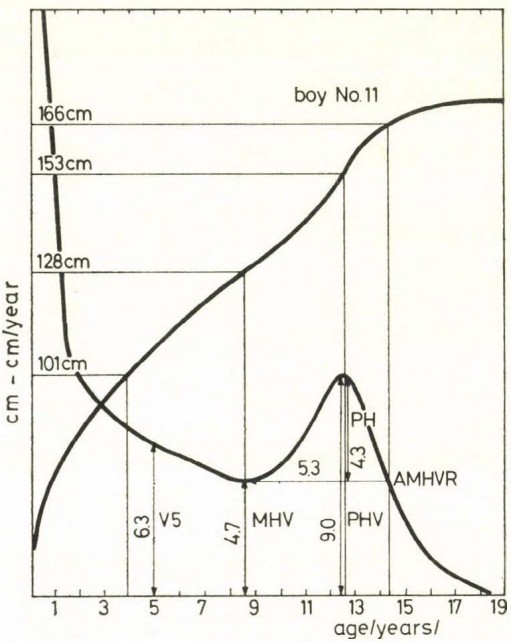

Fig. 2. Stature distance and velocity curves of a boy No. 11. Some of the parameters described in the paper, which are used in analysing individual growth rate are shown

at 4 years in both sexes (105.0 cm in boys and 103.5 cm in girls), height velocity at 5 (males 6.7 cm/yr, females 6.8 cm/yr) and to a certain extent the peak basis (4.6 yrs in males and 4.0 yrs in females). Dissimilarities in both sexes are to be seen in all other parameters — ages, heights, velocities and in the peak heights and areas. At the age of the PHV (13.5 yr in boys and 11.4 yr in girls) a difference of 12 cm occurs between the sexes in height which corresponds with the final difference between the sexes in height at an adult age.

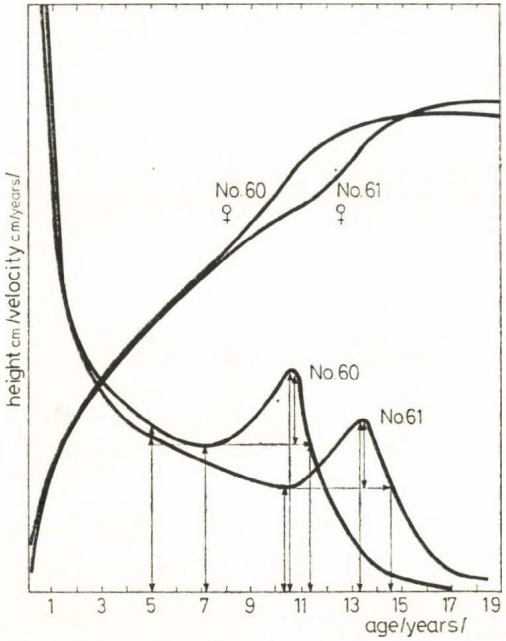

Fig. 3. Stature distance and velocity curves of two girls Nos 60 and 61 with a different rate of growth and onset of maturation. From one to seven years of age no difference in growth occurred

Fig. 3 shows distance and velocity curves of two girls: No. 60 an early and No. 61 a late maturer. No. 60 was slightly longer at birth than No. 61 but in the later growth up to 7 years of age no difference neither in the growth pattern nor in height itself were noticed. Differences in ages at peak height velocities of the two girls amount to three years. The late maturing girl reached a higher final adult height, though at a later age (at 18). The early maturing girl reached her adult height already at the age of 15.

The maximal velocity of growth, achieved during the adolescent spurt — PHV has a biological meaning. The growing organism is at this stage more sensitive than in any other section of growth (with the exception of the first year of life) to ecological factors (increased ecosensitivity). PHV is in girls closely correlated with menarcheal age and thus may help in defining a similar landmark in the body development in boys as is menarche in girls. PHV has a normal (Gaussian) distribution in each sex as shown in Table 2 and in a simplified version graphically in Fig. 4. If we round up our findings the earliest PHV

Table 2

Age at peak height velocity
(Numbers represent individual children from the Prague longitudinal study)

Age (years)	Girls (n = 89)	Boys (n = 89)
9.0	63, 203,	
9.5	3, 8, 36, 37, 110, 246, 252, 282	
10.0	5, 41, 51, 60, 89, 121, 157, 199, 230, 267,	
10.5	26, 48, 130, 163, 202, 266, 274, 276, 281,	9,
11.0	39, 64, 68, 99, 105, 136, 141, 232, 243, 284, 149, 152, 158, 174, 186, 218, 220, 229, 231,	100, 215, 259,
11.5	7, 57, 65, 74, 84, 135, 148, 168, 209, 213, 221,	71, 79, 122,
12.0	4, 30, 54, 66, 67, 102, 111, 126, 127, 156, 171, 191, 192, 262, 264,	11, 123, 271, 157, 189, 257,
12.5	58, 73, 104, 151, 195, 205, 216, 236,	1, 35, 91, 113, 134, 145, 247, 255, 272, 166, 176, 227, 233, 239, 254, 263,
13.0	61, 88, 137, 154,	2, 19, 20, 21, 47, 50, 52, 75, 85, 114, 140, 235, 260, 265, 275, 279,
13.5	59, 76, 82,	14, 24, 45, 55, 72, 117, 128, 234, 253, 285, 172, 177, 196, 201, 208, 210, 219, 268,
14.0		49, 53, 81, 86, 112, 116, 153, 167, 169, 179, 184, 187, 204, 206,
14.5		12, 15, 115, 223, 194, 251,
15.0		6, 40,
15.5		92, 95, 211,
16.0		
16.5		13,

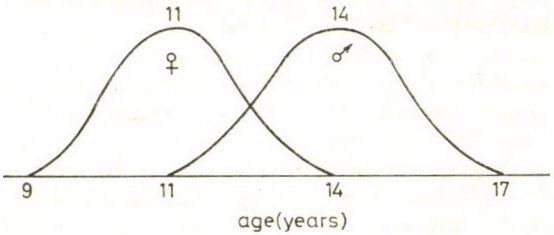

Fig. 4. Schematic age distribution of peak velocity heights in boys and girls from the Prague longitudinal study (age in years)

in girls occurred at 9 years, the mean age for the whole group was 11 years and the highest age of one of the girls from our sample was nearly 14. Boys as a group started to enter the maturation period signified by PHV at the age in which the distribution curve of the girls culminates i.e. at the age of 11. At 13.5 years of age about half of the boys had attained their PHV — nearly at the same age, when already all the girls passed their PHV. The oldest boy from our group who reached his PHV was nearly 17 years old.

Early and late maturers

We have selected from our samples amounting to 89 boys and 89 girls four groups: six most early and six most late maturers from each sex. Their distance and velocity curves are shown in Figs 5 and 6. Early maturing boys were those, whose PHV was below 12 and girls below 10. Late maturing boys were those, who attained their PHV after 15 and girls after 13 years of age. The means of the investigated parameters of velocity curves for each group are given in Table 3. Similarly as in comparing the mean parameters of velocity curves of boys and girls from the original samples, smallest differences were found between both sexes and between early and late maturers within each sex in heights at the age of 4 and in growth velocity at 5 years of age. Sex differences were in these and some other parameters smaller than those between early and late maturing groups within each sex. The mean age at menarche was 11.8 ± 1.1 year in the early and 14.4 ± 1.6 year in the late maturing girls.

Somatotypes after SHELDON et al. (1954) were estimated from photographs in each child at the age of 16 to 18 years. Ectomorphy was found to be more frequent in both sexes in late maturers than in early maturers. In early maturers endomorphy was prevalent in girls before mesomorphy and ectomorphy;

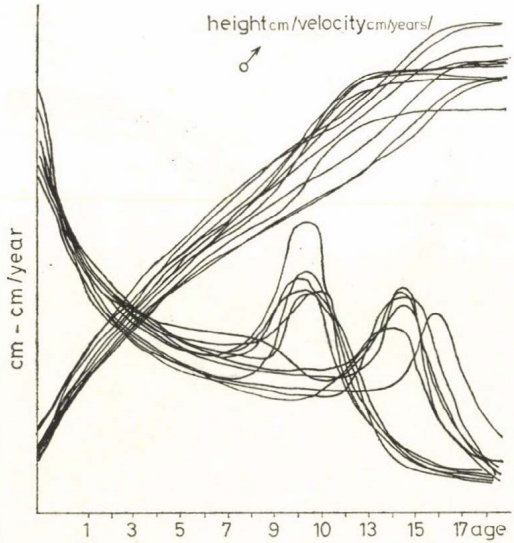

Fig. 5. Individual stature distance and velocity curves of early and late maturing boys

Table 3

Mean parameters of velocity curves in early and late maturing boys and girls

Parameter No. Symbol	Boys maturing		Girls maturing	
	early	late	early	late
1. AMHV (yr)	8.8	12.6	7.1	11.0
2. APHV (yr)	11.6	15.7	9.5	13.4
3. AMHVR (yr)	13.5	17.4	11.2	14.4
4. H 4 (cm)	103.9	104.3	102.7	104.7
5. HMHV (cm)	133.9	150.1	124.0	145.9
6. TAG (cm)	33.5	27.2	28.5	19.1
7. HPHV (cm)	153.1	167.0	140.5	158.5
8. HMHVR (cm)	167.4	177.3	152.5	165.0
9. HA (cm)	172.9	180.8	164.2	170.8
10. V 5 (cm/yr)	6.9	6.4	7.1	6.6
11. MHV (cm/yr)	5.0	4.0	6.1	4.7
12. PHV (cm/yr)	8.9	7.3	7.9	6.2
13. PH (cm)	4.0	3.4	1.8	1.7
14. PB (yr)	4.7	4.8	4.1	3.5
15. PAR (PH × PB)	19.1	16.5	7.9	6.0

Boys — early maturing: PHV before 12 years (n=6)
— late maturing: PHV after 15 years (n=6)
Girls — early maturing: PHV before 10 years (n=6)
— late maturing: PHV after 13 years (n=6)

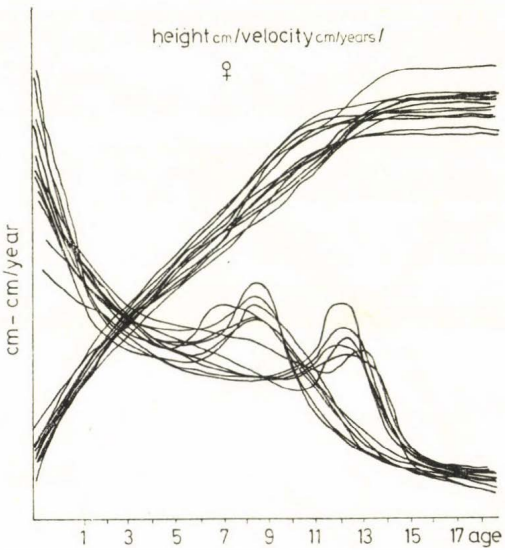

Fig. 6. **Individual stature distance and velocity curves of early and late maturing girls**

mesomorphy prevailed in boys before endomorphy and ectomorphy. In late maturers of both sexes endomorphy dominated over ectomorphy and over mesomorphy more distinctly in girls than in boys. The late maturers as a group were less pigmented than the early ones, who had darker eyes.

It is interesting to note an unimportant role of different social background of the children investigated in relation to early or late onset of maturation. School progress was found to be slightly better in the late than in the early maturers. Average school progress was in general worse during the adolescent period than before and after puberty. Girls revealed better average school achievement than boys.

The psychologist of our research team, H. HAVLÍNOVÁ applied the High School Personality Test after Cattell to each child at the age of 15, 16 and 17 years of age with the aim to obtain the personality characteristics in each child in the adolescent period. HSPQ concerns 14 bipolar factors of personality (28 characteristics). The early maturing girls with PHV before 10 years and boys before 12 years of age were characterized by relaxed, unfrustrated behaviour with advanced social maturity and were found to be emotionally stable. On the other hand the late maturing boys and girls were emotionally unstable and socially immature. Boys from the late maturing group were in contrast to the girls of the same group shy and introverted. The characters of the late maturers may be explained as a result of discrepancy between uniform constant social demands for the group of the same age and the slow rate of biological maturation. No big differences between early and late maturers were found in the later choice of their professional career.

Comparison with other longitudinal studies

Tab. 4 brings results from European and American growth studies (after MALINA 1978, rearranged and completed). Parameters of the Prague velocity curves are close to those from Zürich. The next similar group in many respects is that from Harvard and of Harpenden (though the Harpenden group is of lower mean stature). Children from the Fels, USA and Berkeley studies are on the average taller than the European and Harvard samples.

Discussion

The age span in which individual boys and girls differ in reaching their PHV, is about 5 years in girls and 6 years in boys. Between the most early maturing girl and most lately maturing boy there is a span of 8 years. This knowledge of the wide range of variability in the onset of puberty in still normal children gives to each pediatrician a strong argument in explaining individual situation in deviant cases at a certain age. Pedagogical staffs in schools may benefit from this fact when dealing with children of the same chronological age but of a very different biological age who sit next to each other in the same classroom. School has the same demands for all children of the same age disregarding their different stage of biological development. Some children may be thus wrongly classified be it in mathematics or in physical education.

The question arises whether it is good or not to be an early maturer. It seems that in some cases it may have a positive effect on personality development –

Table 4

Selected parameters of growth curves in various longitudinal studies (after MALINA 1978, rearranged and completed)

Study		Height at minimal prepubertal growth velocity HMHV (cm)			Total gain during puberty period TAG (cm)		Peak height velocity PHV (cm/yr)		Age at peak height velocity APHV (years)		Adult height HA (cm)	
		n	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Boys												
1. Prague	(1)	89	143.6	7.4	30.7	4.8	8.6	1.1	13.5	1.0	178.9	6.1
2. Zürich	(2)	112	143.8	7.7	29.2	—	9.0	1.1	13.9	0.8	177.4	6.3
3. Fels	(3)	83	149.9	7.0	30.9	4.3	7.0	1.1	13.0	0.9	180.9	5.6
4. USA	(4)	54	149.4	7.1	31.0	4.7	6.9	1.1	13.3	0.9	180.4	5.4
5. Berkeley	(5)	65	150.6	7.0	30.1	5.4	6.6	1.0	13.1	1.1	180.7	6.6
6. Harvard	(6)	54	147.4	5.7	31.2	5.5	7.1	1.3	12.3	0.9	178.6	6.1
7. Harpenden	(7)	55	146.1	6.3	27.6	3.5	8.8	1.1	13.9	0.8	173.6	6.1
Girls												
1. Prague	(1)	89	134.2	7.3	25.6	5.0	7.5	0.9	11.4	1.1	167.1	5.8
2. Zürich	(2)	110	135.8	7.3	23.2	—	7.1	1.0	12.2	1.1	164.9	5.7
3. Fels	(3)	74	138.6	7.4	29.5	6.8	6.3	0.9	11.0	0.8	168.0	5.1
4. USA	(4)	49	137.3	6.6	31.0	4.0	6.5	0.9	11.0	0.9	168.2	6.7
5. Berkeley	(5)	64	141.8	7.6	26.3	5.7	5.7	0.8	11.0	0.8	168.1	6.2
6. Harvard	(6)	54	140.3	7.2	25.4	5.6	6.2	1.1	11.1	0.9	165.7	5.1
7. Harpenden	(7)	35	137.9	7.0	25.3	4.1	8.1	0.8	11.9	0.9	163.2	5.9

1. Prague — PROKOPEC, TOMÁŠEK 1979
2. Zürich — STÜTZLE et al. 1977
3. Fels Research Institute, Yellow Springs
4. Child Research Council USA
5. Berkeley Growth Study
6. Harvard School of Public Health
7. Harpenden Growth Study, England

early maturing children are less problematic, more easy going, some of them tend to become leaders among their peers (this may bring disappointment in later years, when the late maturers overtake their earlier mature peers). We failed to find a satisfactory answer as to the cause of early maturation. The answer should be sought on a cellular level — in the rate of cell division (mitosis). A certain amount of mitosis must have taken place in the organism before a functioning organ — say hypophysis, thyroid, ovary etc. developed. The role of provoking agents, of heredity, social relations and nutrition etc. on speeding up and/or on slowing down the rate of biological processes in growing organism still remains to be defined.

When observing side by side early maturing and late maturing children and youths (Plate I), early maturers seem to be those living in affluence, unhindered by disease of any sort, well adapted to living conditions they live in. They are swimming in "their well known waters". On the other hand, late maturing individuals seem to be overcoming some difficulties, covert illness not apparent to a clinician, or still adapting to their milieu. We may also view the early maturers as a "quick job" and later maturers as a longer lasting but

"a solid piece of work unhurriedly put together". The answer to this thought would be: investigation into morbidity and longevity of early and late maturing individuals.

Conclusions

1. Individual growth curves of 89 boys and 89 girls from the Prague longitudinal study have been analysed and the results are presented.

2. Fifteen parameters were studied in each individual velocity curve.

3. Attention was paid to the variability of the peak height velocity (PHV). A difference of 5 years in girls and 6 years in boys was found between the earliest and most late maturing individual of the respective sex. Between the earliest maturing girl and latest maturing boy from the studied sample there was a period of 8 years.

4. Selected groups of 6 early and 6 late maturing boys and girls showed little differences in the mean body height before the age of 5 years but big differences at the age of the PHV.

5. The PHV is on the average smaller in late than in the early maturing groups of both sexes.

6. The final mean height at an adult age was found to be bigger in the late than in the early maturers.

7. Differences between most of the studied parameters of velocity curves were smaller between the sexes (averages) than between early and late maturers of the same sex.

8. Lighter pigmentation (eye colour) was found in the late maturers and darker in the early maturers.

9. The late maturers were slightly better in school progress than the early maturers.

10. The late maturing boys were less mesomorphic and more ectomorphic than the early maturing boys. Late maturing girls were less endomorphic and more ectomorphic than early maturing girls.

11. Social background correlated neither with early nor with late maturation. Also the choice of profession (students and apprentices) had no bearing on early or late start of maturation or on its length of duration.

12. The Cattell's HSPQ test performed repeatedly at the age of 15, 16 and 17 years of age showed that the early maturers were unfrustrated, relaxed, emotionally stable and socially mature, whereas the later maturers were socially immature and emotionally unstable. Boys from the late maturing group were also shy.

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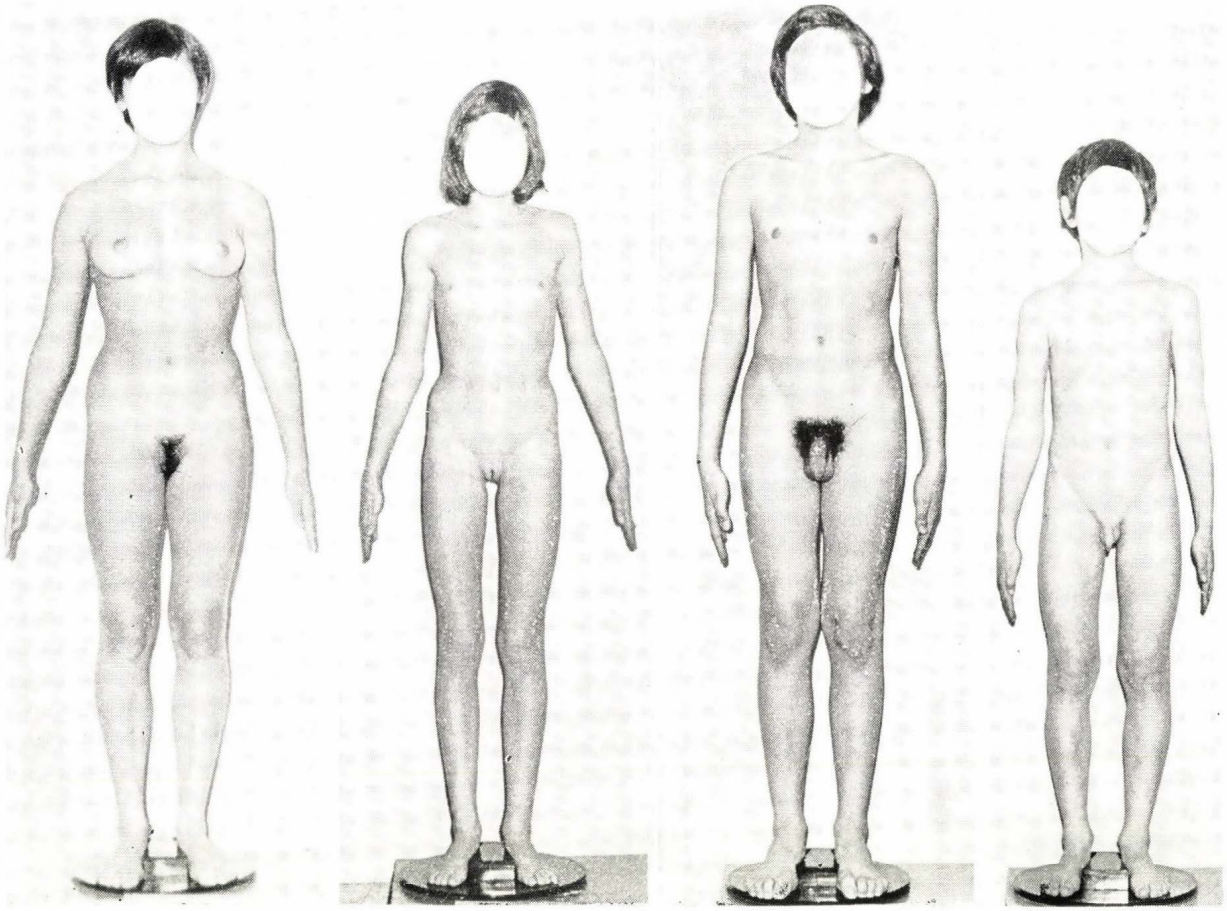

Plate 1: A — early maturing girl, age 12 years, height 162.2 cm, weight 51.1 kg, No. 36, B — late maturing girl, age 12 years, height 149.1 cm, weight 31.8 kg, No. 61, C — early maturing boy, age 13 years, height 159.6 cm, weight 47.1 kg, No. 259, D — late maturing boy, age 13 years, height 137.4 cm, weight 29.8 kg. No. 211

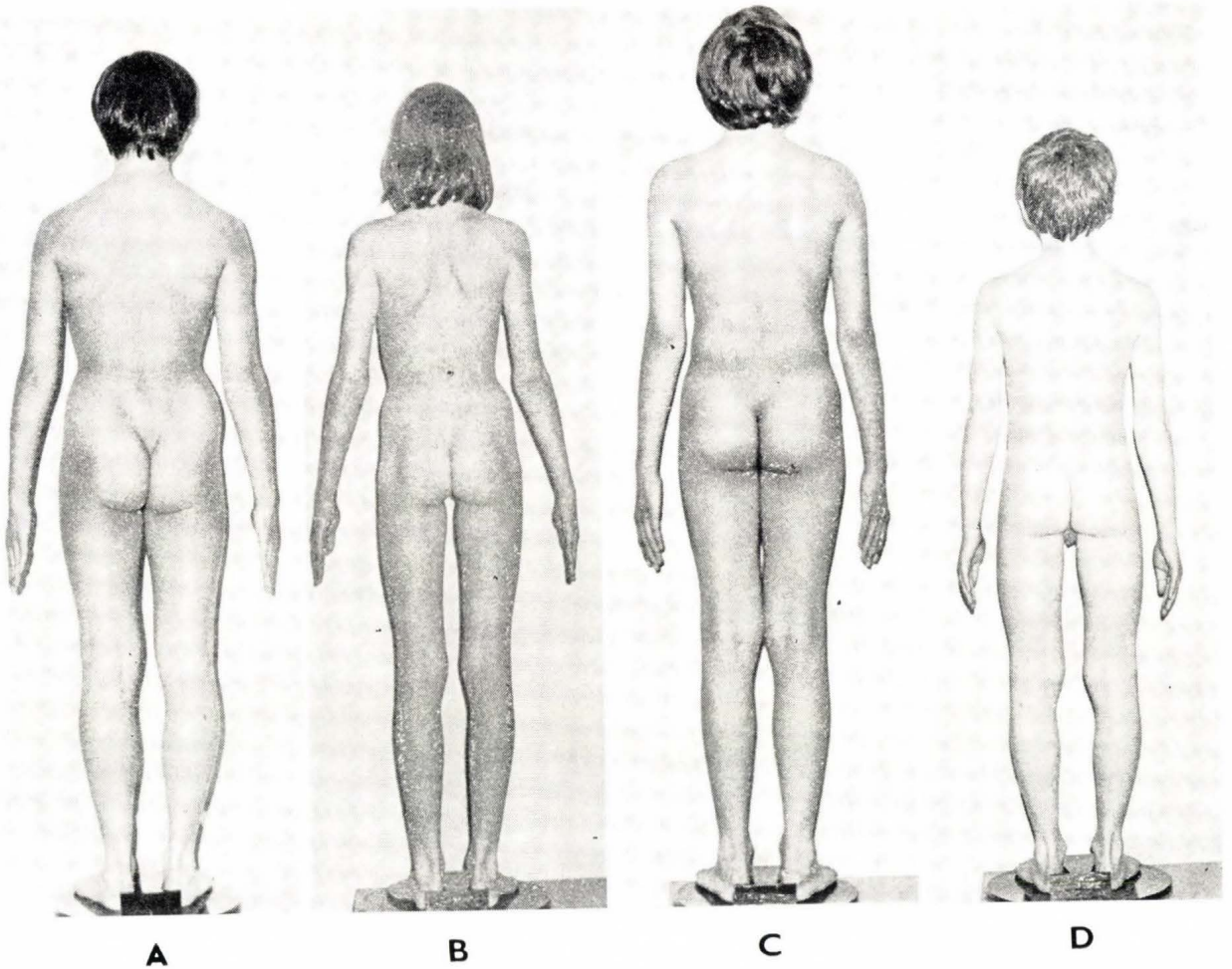

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Plate 2