

ONSET OF PUBERTY IN MZ AND DZ TWINS

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Introduction

Twins have been used to study, among other things, the heredity of biological time. This particular branch of human genetics has been called "chronogenetics" by GEDDA & BRENCI (1975). By this is meant, that each individual has a genetically regulated timing of for instance puberty, ageing and death. The study of similarity in this biological timing for MZ and DZ twin pairs is one method, whereby an estimation of the heredity of biological time can be made.

Earlier studies of somatic maturation have shown that this is strongly genetically regulated in man. The measure used to estimate somatic maturity has mostly been age at menarche. The MZ twins tend to be much more similar than DZ twins for the timing of menarche (PETRI 1935; TISSERAND—PERRIER 1953; GEDDA & BRENCI 1975).

This is an easily accessible measure, but has the disadvantage that it is not possible to make any comparisons between boys and girls. Other criteria of physical maturity, as for instance age at peak height velocity, necessitate a longitudinal study of the individuals — and is therefore very time-consuming. There are very few longitudinal twin studies and only one, as far as I know, where the twins have been followed longitudinally during puberty.

Materials and methods

In 1964 a longitudinal study of physical and mental growth in twins and controls of matched age (the SLU-project)* started at the Department of Educational Research at the Stockholm School of Education. The results presented in this paper have been collected in the SLU-study. The twins were taken from the 40 largest cities and towns in Sweden and their controls were attending the same classes as the twins. Originally, the sample consisted of 94 pairs of MZ twins, 133 DZ of the same sex, 96 DZ of different sex and 1194 controls.

Height and weight measurements and a rating of secondary sex characteristics were made twice a year by the school nurses. Individual measurements were thereafter adjusted to specific chronological ages. The school nurses also asked the girls for the age at which menarche had occurred. To get another estimate of the age at menarche all girls were asked at the age of 17 about their menarcheal age according to the recall method. In addition to this certain

* SLU = Skolöverstyrelsens och Lärarhögskolans Utvecklingsstudie, Follow-up study by the National Board of Education and the Stockholm School of Education of the maturity process in adolescents.

psychological measurements were collected by the school teachers and others. A more detailed description of the project and the methods has been given by LJUNG, BERGSTEN—BRUCEFORS and LINDGREN (1974).

The twins and their controls were followed from grade 3 at approximately 10 years of age to grade 9 at approximately 16 years of age. Since the physical growth had not stopped at that age for many of the boys, additional height and weight measurements were collected for approximately 50% of these up to and including age 18.

For classifying the like-sexed twin pairs a morphological diagnosis according to a special schedule was applied. This schedule is based on earlier investigations of similarity diagnosis in twins (ESSÉN—MÖLLER 1941, NORINDER 1946, HUSÉN 1959). A full description of the zygosity classification of the SLU-twins has been given by LJUNG, FISCHBEIN & LINDGREN (1977).

The methods used in the SLU-project for estimating the age at which different criteria of physical maturity were reached have been thoroughly described by LINDGREN (1975, 1976).

They are:

— “age at peak height velocity (PHV) and peak weight velocity (PWV) according to a modified ‘mid-year-velocity’ method. Individual height and weight measurements were adjusted to specific chronological ages (10.0, 10.5, 11.0 etc.) according to the interpolation method described by OLOFSSON (1972). The yearly increments (to avoid seasonal effects) were then calculated for each 6 months (10.0, 10.5, 11.0 etc.) by taking the yearly increments from 9.5 to 10.5, 10.0 to 11.0 and so on. The midpoint of the 12 months interval during which the maximum yearly increment occurred was taken as age at PHV or PWV. To examine this, individual growth curves were first plotted using a computer program by OLOFSSON and ROSTRÖM (1973) and checked visually” (LINDGREN 1976, pp. 502—503). Twin pairs with very irregular curves and with two or more peaks of about the same size were excluded. There were 7 MZ pairs and 14 DZ pairs excluded for age at PHV and PWV for this reason.

— age at menarche estimated both on basis of the school nurses’ reports and the girls’ own statements (the recall method)

— ages at which five successive stages in the development of the secondary sex characteristics were reached according to ratings made by the school nurses twice a year. “This was done by pictorial criteria after undressing the pupils. In the pictures, however, the breast and pubic hair stages for the girls are combined and so are the genital and pubic hair stages for the boys. The assessment of these pubertal stages can therefore be seen only as rough estimates and cannot readily be compared with results from other investigations (MARSHALL & TANNER 1969, 1970)” (LINDGREN 1976, pp. 502—503).

The five stages used to rate the development of secondary sex characteristics can verbally be described in the following way for the girls (translated from LINDGREN 1975, pp. 47—48):

1. Preadolescent; no pubic hair; no breast development.
2. Sparse growth of long, slightly pigmented hair over mons veneris. Breast bud stage; elevation of breast and papilla.
3. Considerably darker, coarser and more curled pubic hair sparsely spread over mons veneris.

Further enlargement of breast and areola, with no separation of their contours.

4. Hair is now adult in type, covering mons veneris.

Projection of areola and papilla and enlargement of the breast.

5. Adult hair in quantity and type spread to the medial surface of the thighs.

Mature breast stage; projection of papilla only, due to recession of the areola to the general contour of the breast.

For the boys (translated from LINDGREN 1975, p. 70):

1. Preadolescent; no pubic hair.

2. Sparse growth of long slightly pigmented hair over mons veneris.

The scrotum and testes have enlarged and there is a slight change in the texture and quality of the scrotal skin.

3. Considerably darker, coarser and more curly hair over mons veneris.

Growth of the penis as well as scrotum and testes.

4. Hair of adult type limited to mons veneris.

Penis further enlarged in length and breadth and also further darkening of the scrotal skin.

5. Adult hair in quantity and type, with spread to the medial surface of the thigh.

Genitalia adult in size and shape.

Correlation coefficients between ages at which different criteria of physical maturity are reached are reported by LINDGREN (1975). The correlation, for instance, between age at stage 4 and at PHV is .63 for girls and .76 for boys.

Results

Peak height velocity (PHV)

A comparison of the similarity in MZ and DZ twin pairs for age at PHV can contribute to the understanding of the role of hereditary factors in physical maturation. Since MZ twins have the same genetic make-up, they are expected to be similar in the timing of genetically based developmental features. The DZ twin pairs, on the other hand, should not be more similar than ordinary siblings in this respect.

Table 1 gives the average intra-pair differences and intra-pair correlation coefficients* in age at PHV for MZ and DZ twin pairs.

Approximately 85–90% of the twin pairs had complete height measurements for both twins in the pair, so that an estimation of age at PHV could be accomplished. This means that there is a very small loss of individuals among the twins during the period of investigation.

The average intra-pair difference for the MZ twins in age at PHV is 0.4 years and for the DZ pairs approximately 0.7 years. The intra-pair correlation is for MZ around 0.8 and for DZ 0.4. The height spurt, thus, seems to take place much more simultaneously for the MZ pairs than for the DZ.

* The formula used for estimating the intra-pair correlations is

$$r = \frac{V_{bp} - V_{wp}}{V_{bp} + V_{wp}}$$

r = intra-pair coefficient
V_{bp} = variance between pairs
V_{wp} = variance within pairs

For a more detailed discussion of this method see LJUNG (1966).

Table 1

Average differences and intra-pair correlations (r) in age at PHV for MZ and DZ twin pairs
 1. táblázat. Az egytétű és kétetű ikerpárok hossznövekedési lökések időpontjában mutatkozó átlagos különbségek (években) és a páron-belüli korrelációk (r)

	MZ				DZ				Diff. MZ-DZ	z
	M_{diff} (years)	SD	N	r	M_{diff} (years)	SD	N	r		
Boys	0.45	0.45	43	0.85	0.78	0.63	60	0.42	-0.33	-3.30***
Girls	0.40	0.49	39	0.78	0.69	0.73	60	0.39	-0.29	-2.41**

N = number of pairs = a vizsgált párok száma

Table 2

Average differences and intra-pair correlations (r) in peak height (cm/year) for MZ and DZ twin pairs

2. táblázat. Az egytétű és kétetű ikerpárok hossznövekedési lökésében (cm/év) mutatkozó átlagos különbségek (években) és a páron-belüli korrelációk (r)

	MZ				DZ				Diff. MZ-DZ	z
	M_{diff} (cm/year)	SD	N	r	M_{diff} (cm/year)	SD	N	r		
Boys	0.80	0.55	42	0.75	1.18	0.83	60	0.43	-0.38	-2.92***
Girls	0.87	0.69	37	0.48	1.06	0.87	57	0.48	-0.19	-1.26

The average peak height (cm/year) for MZ and DZ pairs is shown in Table 2.

For the twin boys the peak height is more similar among the MZ pairs than among the DZ. The average intra-pair difference in maximal height increase is for MZ 0.8 cm/year and for DZ 1.2 cm/year. The intra-pair correlations are 0.8 for MZ and 0.4 for DZ. For the girls, however, this difference is much smaller (0.8 and 1.1 cm/year) and insignificant. The intra-pair correlations for MZ and DZ are exactly the same for the girl pairs ($r = 0.48$).

Peak weight velocity PWV

Average intra-pair differences in age at PWV for MZ and DZ twins are presented in Table 3. The intra-pair correlations for MZ and DZ pairs are also given.

Table 3

Average differences and intra-pair correlations (r)
 in age at PWV for MZ and DZ twin pairs

3. táblázat. Az egytétű és kétetű ikerpárok súlynövekedési lökésének időpontjában mutatkozó átlagos különbségek (években) és a páron-belüli korrelációk (r)

	MZ				DZ				Diff. MZ-DZ	z
	M_{diff} (years)	SD	N	r	M_{diff} (years)	SD	N	r		
Boys	0.65	0.78	43	0.68	0.88	0.78	60	0.38	-0.23	-1.64
Girls	0.34	0.52	38	0.83	0.84	0.92	57	0.50	-0.50	-3.85***

The maximal weight gain seems to take place more simultaneously for the female pairs than for the male pairs. This is especially true for the MZ twin girls, where the average intra-pair difference for age at PWV is only 0.34 years. For the twin boys the difference between MZ and DZ is not significant. The intra-pair correlations also show the MZ twin girls to be more similar ($r = 0.83$) than the MZ twin boys ($r = 0.68$). This trend is also evident for the DZ pairs (girls = 0.50 and boys = 0.38). A possible explanation for the lower male correlations could be that the boys tend to have a double weight peak (LINDGREN 1975).

The average difference in maximal weight gain (kg/year) is presented for the MZ and DZ twin pairs together with the intra-pair correlations in Table 4.

Table 4

Average differences and intra-pair correlations (r) in peak weight (kg/year) for MZ and DZ twin pairs

4. táblázat. Az egyiptetűjű ikerpárok súlynövekedési lökésében (kg/év) mutatózó különbségek (években) és a páron-belüli korrelációk (r)

	MZ				DZ				Diff. MZ-DZ	z
	M _{diff} (kg/year)	SD	N	r	M _{diff} (kg/year)	SD	N	r		
Boys	0.90	0.69	43	0.76	1.28	1.00	57	0.48	-0.38	-2.37**
Girls	0.88	0.76	36	0.57	1.65	1.14	50	-0.07	-0.77	-4.27***

The average intra-pair difference in peak weight for MZ twins is approximately 0.9 kg/year. Among the DZ pairs the difference tend to be smaller for the boys (1.3 kg/year) compared to the girls (1.7 kg/year). The intrapair correlations also show a zero correlation for the DZ twin girls ($r = -0.07$), while the correlation for the DZ boys is substantial ($r = 0.48$).

Age at menarche

Age at menarche is based both on information from the school nurses and the girls' own reports at 17 years of age. If the nurses' information was available this date has been used (for 20 MZ pairs and 36 DZ pairs), otherwise the girls' own reports have been taken for granted. A comparison of the two measurements (school nurses' and the girls' own reports) has been made by BERGSTEN-BRUCFORS (1976).

According to the first method the mean for the menarcheal age was $m = 12.94$ year (SD = 1.02) and according to the second one $m = 12.97$ year (SD = 1.16).

Table 5 gives the average intra-pair differences and correlations for age at menarche for MZ and DZ twin girls. As can be seen from Table 5 the MZ pairs are very similar for age at menarche. The average intra-pair difference is only 0.29 years and the intra-pair correlation as high as 0.93. The DZ pairs, however, are much less similar (0.71 years on average). The intra-pair correlation for the DZ twins is somewhat higher than would be expected for ordinary siblings on basis of genetical factors alone. Asking the girls will probably raise the

Table 5

Average differences and intra-pair correlations (r)
in age at menarche for MZ and DZ twin pairs

5. táblázat. Az egytétűjű és kétetűjű ikerpárok menarchekorában mutatkozó
átlagos különbségek (években) és a páron-belüli korrelációk (r)

	MZ				DZ				Diff. MZ-DZ	z
	M _{diff} (years)	SD	N	r	M _{diff} (years)	SD	N	r		
Girls	0.29	0.27	28	0.93	0.71	0.66	48	0.62	-0.42	-4.00***

correlation somewhat both for MZ and DZ pairs, since if you don't remember the exact date you will probably check with your sister.

The correlations for age at menarche are very similar to the ones presented by GEDDA & BRENCI (1975). They draw the conclusion from their results, that physical maturity is strongly regulated by hereditary factors.

Ratings of secondary sex characteristics

The ratings of secondary sex characteristics have been made by the school nurses twice a year from 10 to 16 years in connection with the height and weight measurements. The procedure has been described by LINDGREN (1975).

Figures 1 and 2 show the intra-pair correlations for the MZ and DZ twin pairs separately for boys and girls. Figures 1 and 2 show the MZ twins to be more similar in the development of secondary sex characteristics during puberty than the DZ twins. This can be taken as another indication of greater similarity in physical maturation among MZ twins in comparison to DZ. If the whole

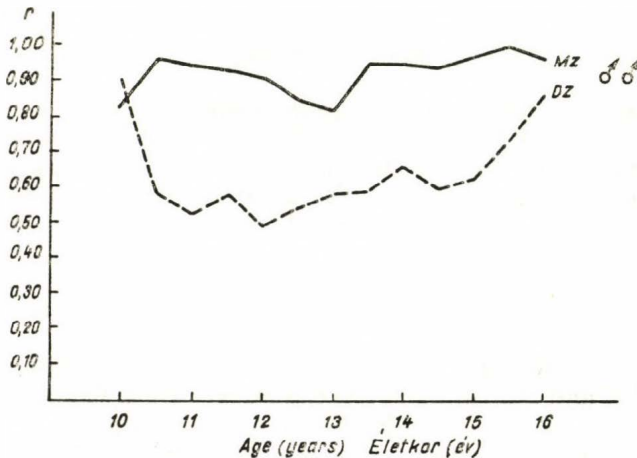


Fig. 1. Intra-pair correlations in ratings of secondary sex characteristics. Boys
1. ábra. Fiúk másodlagos nemi jellegeinek előrehaladásában mutatkozó páron-belüli
korrelációk

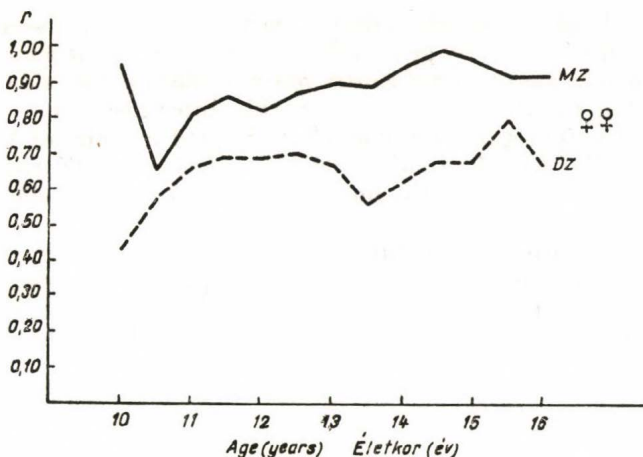


Fig. 2. Intra-pair correlations in ratings of secondary sex characteristics. Girls
 2. ábra. Leányok másodlagos nemi jellegeinek előrehaladásában mutatkozó páron-belüli korrelációk

period of development of the secondary sex characteristics had been covered, the correlations would approach unity both for MZ and DZ pairs in the beginning and end of the investigation period. As can be seen from Figure 1 and 2 the whole growth period of the secondary sex characteristics has been covered more fully for boys than for girls.

Discussion

A comparison has been made in this paper of the temporal regulation of physical maturation in MZ and DZ twin pairs. The measures used to estimate physical maturity in the SLU-project are age at peak height velocity, age at menarche and ratings of the development of secondary sex characteristics. In all these respects the intra-pair differences for MZ twins are much smaller than for DZ twins.

For a group of the SLU-twins (97 pairs) the dental development of the twins, which could also be considered as a measure of physical maturity, has been studied (RYMAN et al. 1975). The results show a greater similarity for MZ twins in dental development in comparison to DZ twins. The authors draw the conclusion, that the results "indicated a strong genetic regulation both in boys and girls".

The physical maturity process during puberty can thus, on basis of results from the SLU-project, be said to be strongly genetically regulated, at least in our western type of cultural environment. It will therefore probably require very extreme environmental effects or severe illnesses to upset this hereditary biological timing.

Age at peak weight velocity also seems to be more simultaneous for the MZ pairs than for the DZ. There is also a rather strong correlation between age at PHV and age at PWV (0.74 for boys and 0.69 for girls), which means that this result could be expected (LINDGREN 1976).

The maximal height or weight gain (in cm/year or kg/year) seems to be less influenced, at least in girls, by genetic factors than the age at which it appears. The maximal height gain is significantly more similar for the MZ boys than for the DZ boys. For the twin girls, however, this difference is not significant.

The maximal weight gain is not at all correlated in pairs of DZ twin girls ($r = -0.07$), while there is a substantial correlation in DZ twin boys ($r = 0.48$). Among the MZ pairs the boys also tend to be more similar than the girls.

A possible explanation to the difference between the sexes in these respects could be the generally lower height and weight spurts, on average, for girls in comparison to boys (LINDGREN 1975). This would mean, of course, that the differences within pairs of twins in peak height or peak weight would also be smaller on the average.

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A PUBERTÁS BEKÖVETKEZÉSE EGY- ÉS KÉTPETÉJŰ IKREKNÉL

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(Összefoglalás)

A szerző egy ikervizsgálatot mutat be, amellyel a hossz- és súlynövekedésben, valamint a menarchekorban és a másodlagos nemi jellegek kifejlődésében megmutatkozó variációkat előidéző genetikai tényezők jelentőségét elemzi. A vizsgálat eredményei alapján nyilvánvaló, hogy a pubertás megjelenése eléggé erősen a genetikai szabályozás függvénye. A maximális hossz- és súlygyarapodást (cm/év-ben, ill. kg/év-ben kifejezve) a genetikai tényezők látszólag kevésbé befolyásolják — legalábbis a leányoknál — mint az életkort, amelyben az megjelenik.

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