

# SOME GENETIC PROBLEMS IN PHYSICAL GROWTH AND DEVELOPMENT

## A Longitudinal Study on Children Aged 0-7 Years

HANNA M. CHRZASTEK-SPRUCH

Pediatric Institute of Medical Academy, Lublin, Poland

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*Aiming at determining the influence of some genetic factors on growth and development, a longitudinal study of 180 children (90 M and 90 F) from the city of Lublin was carried out, with periodical medical examinations and anthropometric measurements from birth to 7 years of age. The parents of each child were also examined.*

*The correlation coefficients between parents and children show that, as regards height, the greatest similarity occurs between mothers and daughters, and a lesser one between fathers and sons. As regards weight, sons are more similar to fathers than daughters to mothers.*

*The relationship between the growth and development of children and the mating type of parents, parental age, and birth order, was also investigated. In negative assortative mating, the children are taller than the children of middle-height parents from positive assortative mating couples. Children (especially daughters) of tall mothers and short fathers grow taller than children of tall fathers and short mothers.*

*Finally, the dependence of growth on parental age and birth order was analysed and the conclusions reached were quite interesting.*

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### INTRODUCTION

The present study concerns the influence of some genetic factors on the growth and development of children. As is generally known, a useful method in genetic studies consists in observing likenesses between parents and children together with the development of the offspring of a given couple. However, the results obtained by different authors evaluating the degree of correlation between parents and offspring during the latter's growth vary. This is possibly because the various investigations are conducted on different material and with different measuring techniques.

The longitudinal character of the present study made it possible to observe the correlation between parents and children from birth up to the age of seven. As the investigation is continued, it is hoped that the same children may be observed through to full maturity.

### MATERIAL AND METHOD

A longitudinal study was carried out of 180 children (90 M and 90 F) born to parents living in the city of Lublin between September 1964 and May 1965, and examined periodically from birth up to the age of seven. Newborns were examined in obstetrical wards; later, they had control examinations in the Growth Clinic, every month in the first year of life and every three months in the following years.

CODEN: AGMGAK 26 205 (1977) — ISSN: 0001-5660  
*Acta Genet. Med. Gemellol.*, 26: 205-219

Each visit in the Clinic consisted of medical examination and anthropometric measurements. The parents of each child were also measured and weighed. The data of all control examinations were fixed within the range of tolerance accepted for each individual age group.

Up to the 18th month, supine length was taken (with a Wolanski liberometer); later on, stature was taken (with a Martin anthropometer).

Since body height is regarded as largely determined genetically, the relationship between the heights of parents and children was investigated. The investigation also included body weight. The relationship was expressed by means of correlation coefficient. Besides correlation on single parental features, multiple correlations were calculated on a pair of parental features (e.g., height of daughter vs. height of father and mother, or height of daughter vs. height and weight of mother). The parent-child correlation was investigated at birth, at 3, 6, 9, 12, 15, and 18 months, and then at 2, 3, 4, 5, 6, and 7 years. The correlations were calculated between father-son (F-S), father-daughter (F-D), mother-son (M-S) and mother-daughter (M-D) at each age. They are illustrated by Figs. 1-4.

## RESULTS AND DISCUSSION

### 1. Stature and Parental Height

It has been found that the closest correlation occurs between mother and daughter. The body height of daughters in the whole of the investigated period depends significantly on the stature of mother (Fig. 1). This relationship is already observable at birth: the corre-

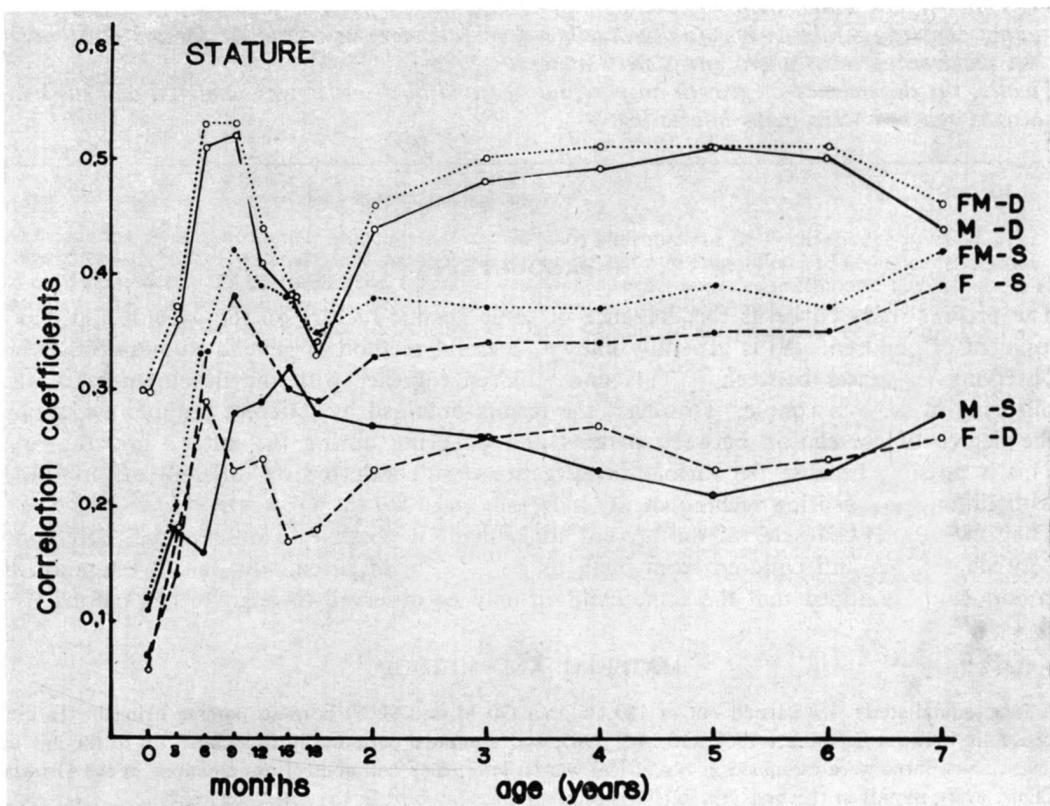


Fig. 1. Parent-offspring correlation coefficients for stature.

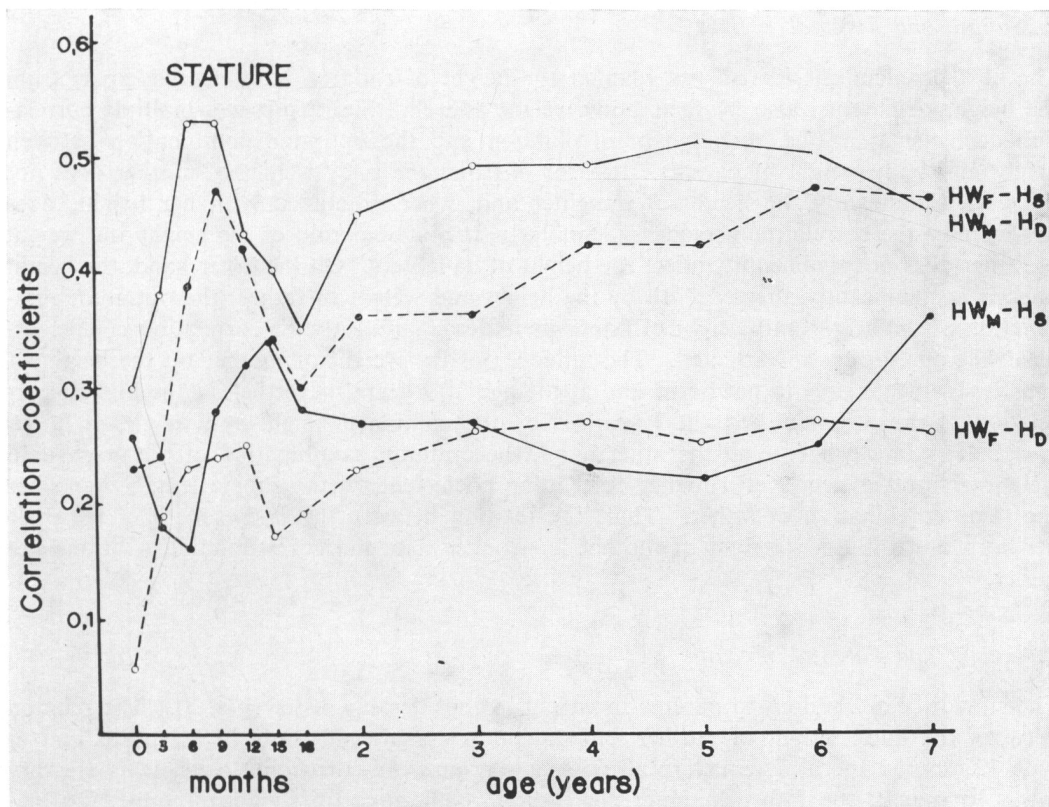


Fig. 2. Multiple correlation coefficients for stature of children ( $H_D$ ,  $H_S$  = height of daughter, of son) and optimum combination of stature and weight of parents ( $HW_M$ ,  $HW_F$  = height and weight of mother, of father).

lation coefficient between the stature (supine length) of a female newborn and the stature of mother is significant (0.30). This correlation increases with age, achieving its peak at 9 months, declining temporarily between 15 and 18 months and going up again in the 2nd and further years of life. The correlation between the body heights of father and daughter is considerably lower, but this too increases with age. The low father-daughter correlation is confirmed by multiple correlation: when the stature of father is combined with that of mother, the correlation coefficient between daughter and both parents is not significantly increased.

The father-son correlation is significant only starting with the age of 6 months. The likeness between father and son is less marked than that between mother and daughter: the correlation coefficients are lower. The influence of mother on the stature of son is observable starting with the 9th month, producing significant correlation coefficients. Though the mother-son relationship is weaker than the father-son one, yet it influences the multiple correlation of son on both father and mother which increases significantly. It should be stressed that the correlation coefficients for body height of parents and children are lowest at birth, which indicates that genetic determinants affect height only slightly in the stage of fetal development.

## 2. Stature and Parental Weight

The next problem considered was whether the height of children is influenced, apart from the height of parents, also by their body weight as well. Fig. 2 presents multiple correlation coefficients for the body height of children and the optimum combination between height and body weight of parents. It turns out that the body weight of mother does not influence significantly the height of daughter and, when combined with her height, does not increase the correlation coefficient. Similarly, the combination of the height and weight of father does not significantly affect the height of daughters. On the other hand, the height of sons is significantly affected both by the height and weight of father; the optimum combination of the height and weight of father increases significantly the correlation coefficients in all the age groups investigated. The influence of the weight of mother on the height of sons is significant only in newborns and at the age of 7 years; nevertheless, the highest correlation of the height of sons at 7 years is on the combined height and weight of father ( $r = 0.46$ ). In newborns, on the other hand, the optimum combination of the height and weight of mother produces a higher correlation coefficient on the supine length than does the same combination of father. Thus, the relation between the body length of the male newborn and the body weight of mother is stronger than the corresponding relation with father.

## 3. Weight and Parental Weight

The similarity of children to parents in weight is considerably lesser (Fig. 3). The relation between the body weight of mother and daughter is significant only in newborns and at 3, 9, 12 months and at 7 years. In all other age groups the correlation coefficients are very low. In weight, the father-daughter correlation coefficients are significant only at 6 and 7 years, though the multiple correlation on the weight of both parents increases the correlation coefficients at ages 3 to 7. The weights of father and son are more clearly related, although the relationship is significant only in the first year and at the age 3-7. The mother-son relationship in weight is slight and significant only in newborns and at the age of 7. It should be stressed that, in body weight, there is greater similarity between father and son, and at the age 3-7 also between father and daughter, than between mother and daughter. Another important observation is that there is a high correlation in weight between mother and newborns of both sexes and that it decreases up to the 6th month. This could be expected because body weight in newborns depends largely on intrauterine factors and only slightly on the genotype (Penrose 1961). Subsequent correlation coefficients increase with age.

Many authors (Penrose 1955, Robson 1955, Wolanski 1967 and 1970) stress that the intrauterine development is affected very strongly by the individual peculiarities of the mother, so much so that the genetic dispositions of the fetus are suppressed in a way. Only in later stages does the child's genotype exert an increasing influence and the similarity in physical development to the parents becomes more observable.

Numerous authors unanimously confirm the increasing correlation between the features of parents and offspring as the latter develop (Kagan and Moss 1959, Livson et al. 1962, Tanner and Israelsohn 1963, Charzewska and Wolanski 1964, Furusho 1964, Susanne 1971). In the present investigations, where the results obtained come closest to those of Tanner

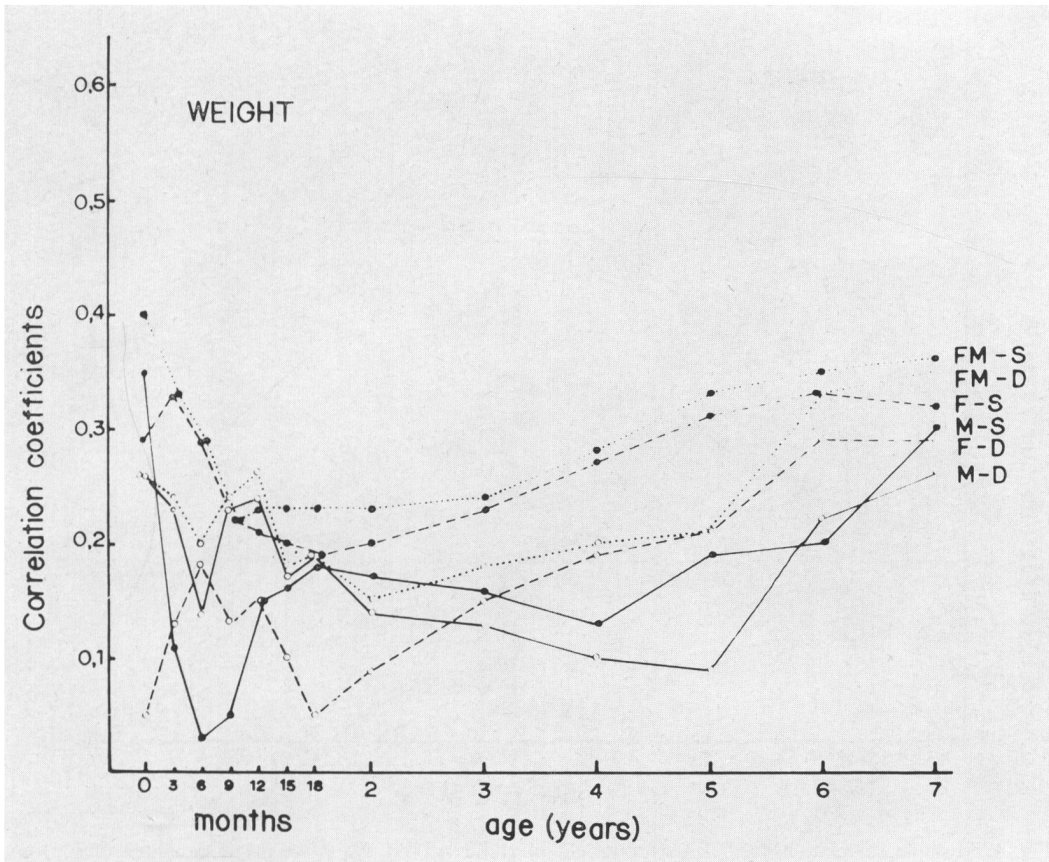


Fig. 3. Parents-offspring correlation coefficients for body weight.

and Israelsohn (1963), the correlation between parents and offspring in stature increases in the first year of life and, after a temporary decline in the 15th and 18th month, it increases again in the 2nd and 3rd year of life and stays on that level in subsequent years. Similarly, as in the investigations of Tanner and Israelsohn (1963), correlation in body weight is highest in newborns.

The use of multiple correlation coefficients made it possible to correlate the characteristics of children with the optimum linear combination of different pairs of parental features. In this way it was found that the height of offspring depends not only on the height of parents but sometimes also on their weight. Further, the weight of offspring was found to be related not only to the weight of parents but also to their stature (Fig. 4).

The literature and the results of the present investigation show that the mother plays the dominant role in shaping the features of the offspring. It seems probable that the maternal regulator not only determines fetal development, but also affects metabolism in postnatal growth and development (Ounsted and Ounsted 1966).

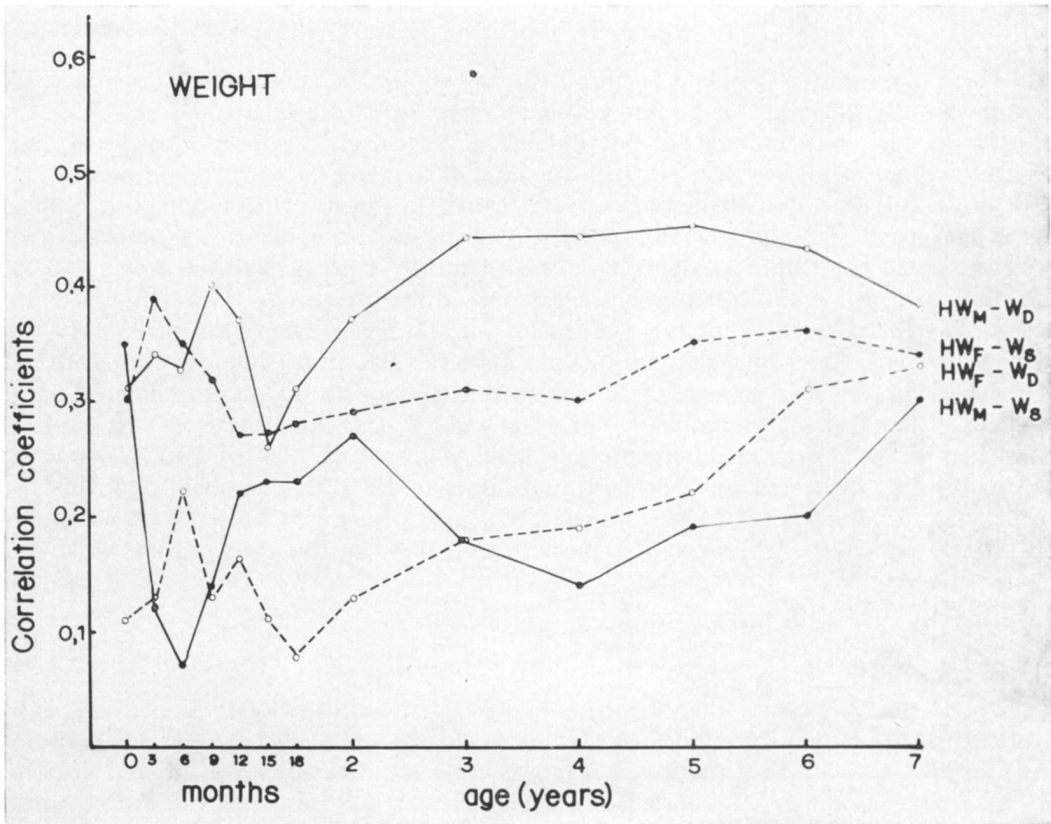


Fig. 4. Multiple correlation coefficients for weight of children ( $W_D$ ,  $W_S$  = weight of daughter, of son) and optimum combination of height and weight of parents ( $HW_M$ ,  $HW_F$  = height and weight of mother, of father).

#### 4. Height, Weight and Parental Mating Type

The next factor taken into consideration was the influence of the mating type of the parents on the child's growth and development. The present investigation showed positive assortative mating of couples in reference to height ( $r = 0.30$ ) and weight ( $r = 0.28$ ).

In order to find how far the parental mating type, with reference to stature, influences the height of offspring, the latter's mean arithmetic values were considered in relation to parental mating type (Fig. 5), adopting three categories of stature: (1) short, (2) moderate, (3) tall. This produced 9 possible combinations of stature in parental couples, with the first figure indicating the stature of father and the second, the stature of mother, i. e.: both spouses short (11), both moderate (22), both tall (33), mother taller than father (12, 13, 23), and father taller than mother (21, 31, 32). Combinations 11, 22 and 33 are homologous, characterized by positive assortative mating, whereas all other combinations are heterologous, characterized by negative assortative mating.

It was found that in all age classes over 3 months the offspring (both male and female) of tall parents are the tallest, the offspring of short couples the shortest, whereas the offspring of parents of moderate stature also reach middle height.

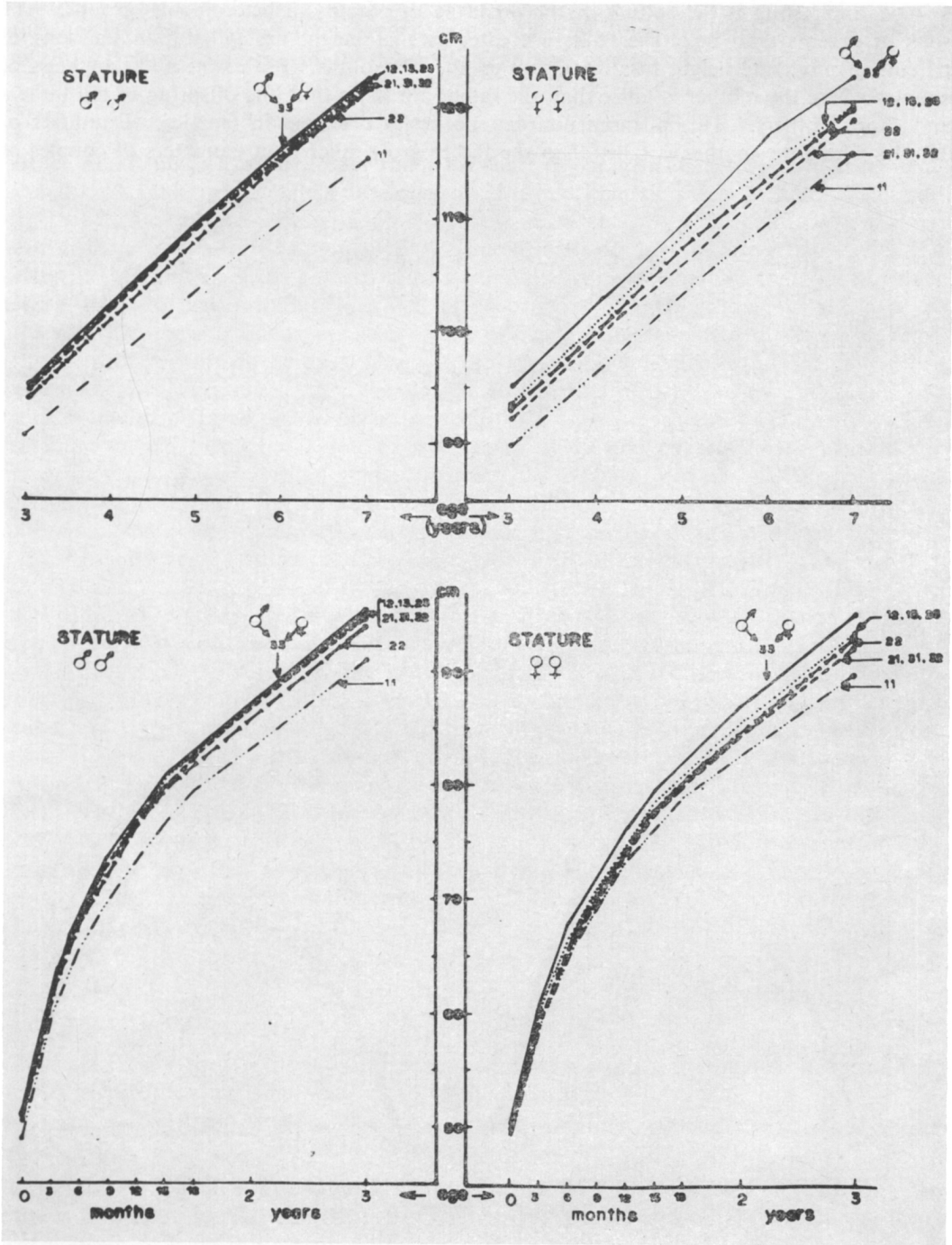


Fig. 5. Growth curves of stature in boys and girls in relation to parental mating type.

What is interesting is the stature of the offspring of parents in heterologous groups. The sons of parents who belong to different categories of height are taller than the sons of parents of moderate height in all age groups after 3 months. Both sons and daughters of couples where the mother is taller than the father are taller than the offspring of tall fathers and short mothers. This phenomenon can be better observed in females. Daughters of couples where the mother is taller than the father grow taller than daughters of couples of

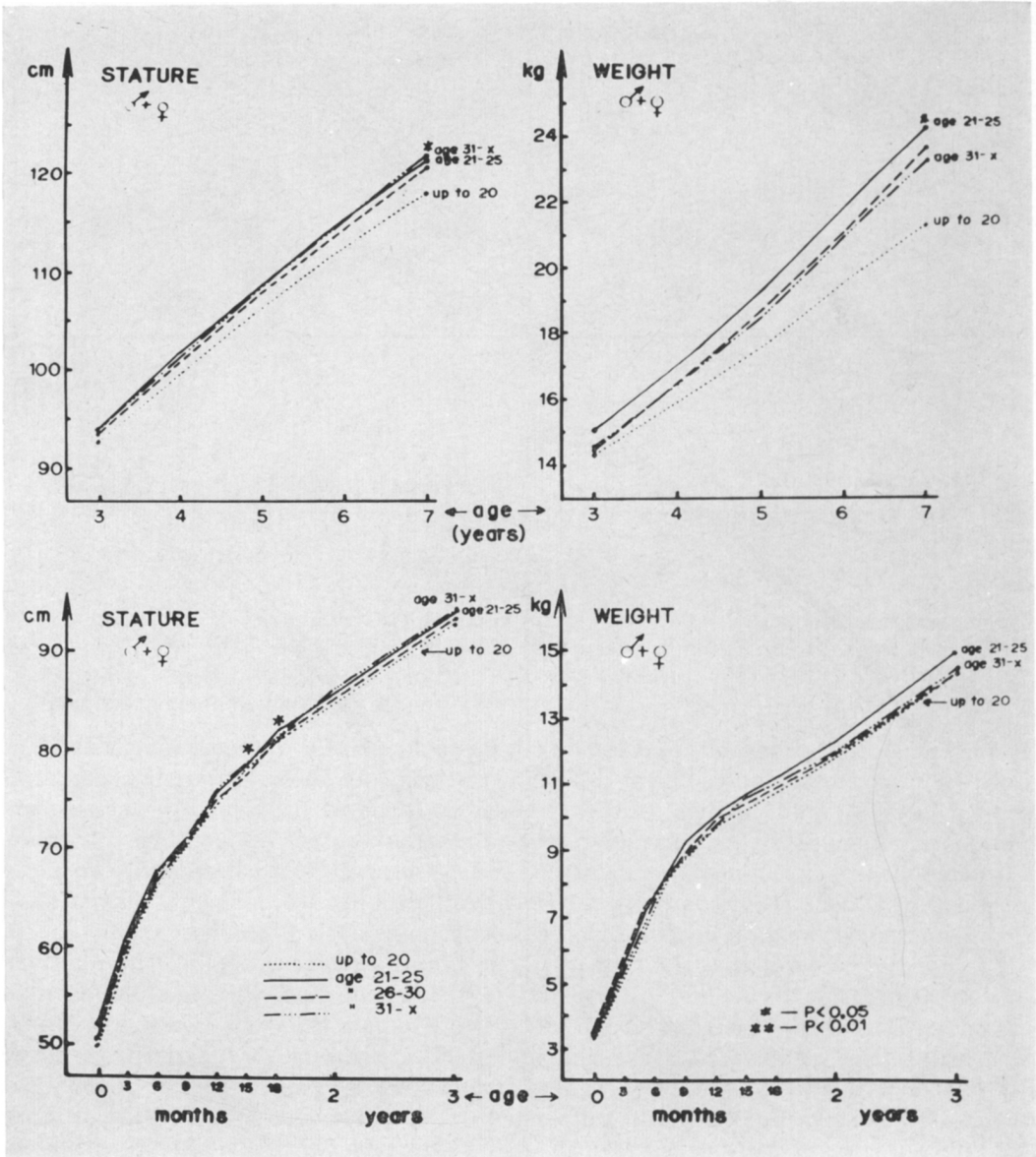


Fig. 6. Growth curves of stature and weight of children in relation to maternal age.



moderate height and, inversely, daughters of couples where the mother is shorter than the father are invariably shorter than daughters of couples of moderate height. These findings confirm a stronger influence of the mother's genotype, especially so in daughters.

### 5. Height, Weight and Paragenetic Factors

Further, an attempt was made to determine the share of paragenetic factors, such as parental age and birth rank, in the child's development. Mean arithmetic values of body height and weight of offspring were compared mutually in separate categories of age of parents. The mean arithmetic values being similar for boys and girls, the two sexes were pooled. The results show a slower development of the offspring of the youngest mothers, aged under 20 (Fig. 6). The highest stature was that of offspring of mothers aged 21-25 and over 30 (up to 41); the highest weight was achieved by offspring of mothers aged 21-25. This regularity has been confirmed by an analysis of the rate of growth of offspring of mothers in the same age categories (Fig. 7). The slowest growth rate of body weight and height was found in the offspring of youngest mothers, up to 20 years; the highest increase of stature was found in children whose mothers were 21-25 or 31 and over at birth; whereas the highest increase of weight was found in offspring of mothers aged 21-25. The differences between mean arithmetic values are statistically significant in many age classes. Thus, on the basis of the present analysis, it seems that the best child-bearing age of the mother is 21-25, whereas the age below 20 affects the growth of offspring adversely.

The relations between the age of father and the weight and height of offspring (Fig. 8) are statistically insignificant in the whole investigated period; yet, between 6 months and 7 years the best physical development was found in children of fathers aged 30-34. This observation tallies with the results of the investigation of Charzewska and Wolański (1964).

When birth rank was investigated, it was found that first-borns are lighter and shorter than second and further children (Fig. 9). Up to the 18th month, the tallest and heaviest are second children. From age 18 months till 6 years, the slowest physical development was found in third and further children, whereas the growth curves of first and second-borns are similar. An investigation of the dynamics of growth (Fig. 10) showed that, in the whole investigated period, the fastest growth, both of body weight and height, occurred in first-borns, and the slowest in third and further children. The differences are statistically significant in many age classes. The fast growth of first-borns can explain why these children achieve a higher level of physical development in spite of their low height and weight at birth.

### CONCLUSIONS

1. The closest correlation for stature was found between mother and daughter, and a lesser one between father and son, whereas the father-daughter correlation is low.
2. In body weight, there is a greater similarity between father and son than between mother and daughter.
3. The use of multiple correlation coefficients increases the possibility of predicting the features of a child in relation to those of the parents: height and weight are chiefly determined, in girls by the stature of mother, and in boys by the stature and body weight of father (and, to a lesser degree, by those of the mother).

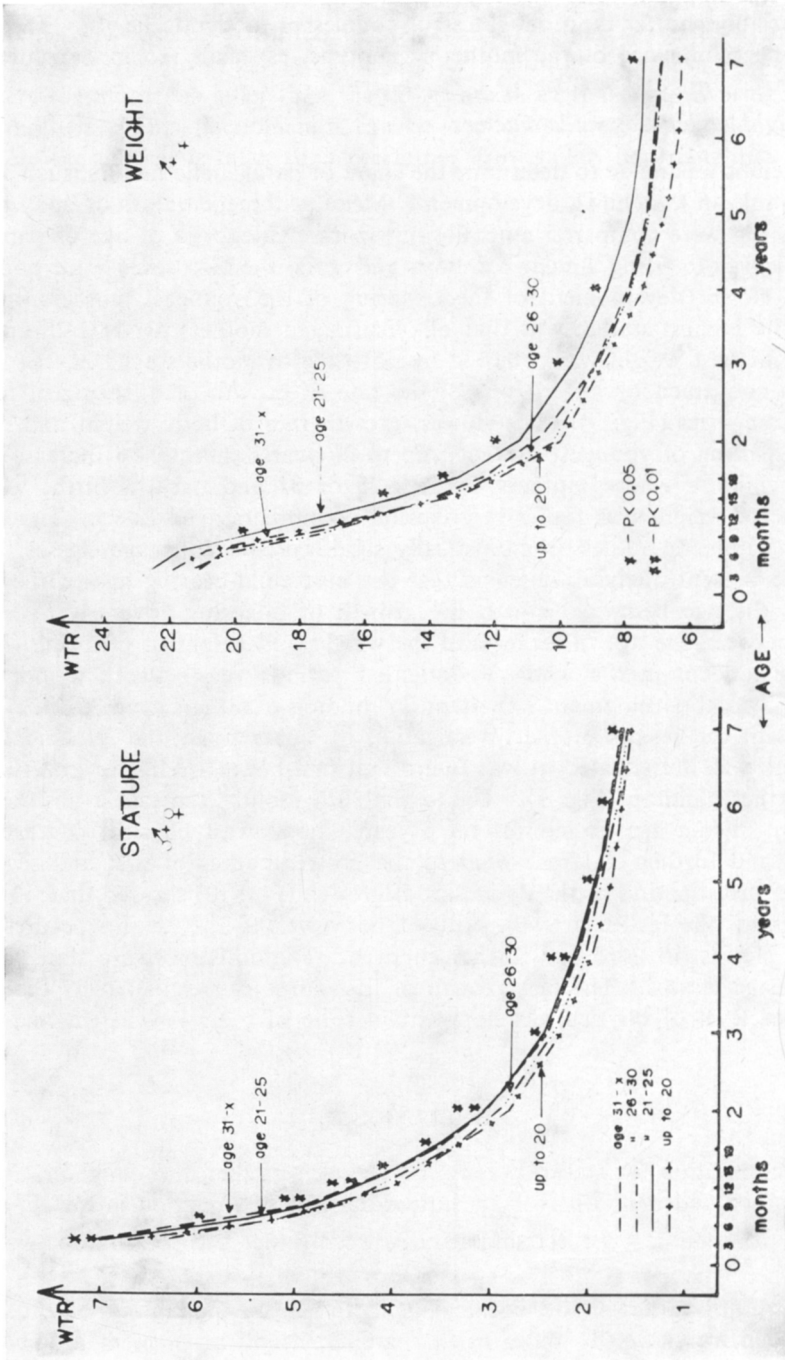


Fig. 7. Growth rate of stature and weight of children in relation to maternal age.

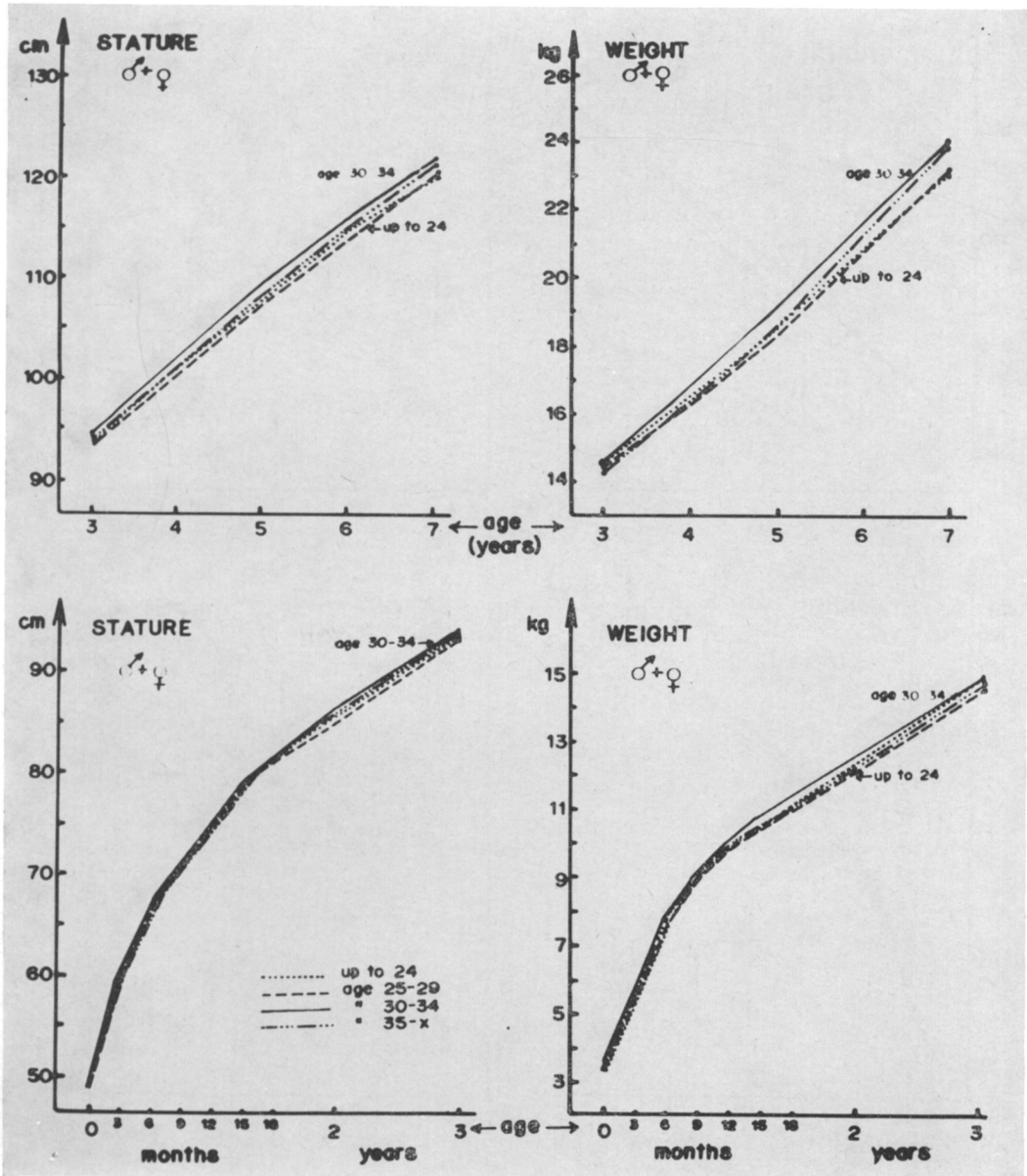


Fig. 8. Growth curves of stature and weight of children in relation to paternal age.

4. The relationship between the genetically determined features of parents and children increases with age, as the child moves away from the dependence on the mother in the fetal period.

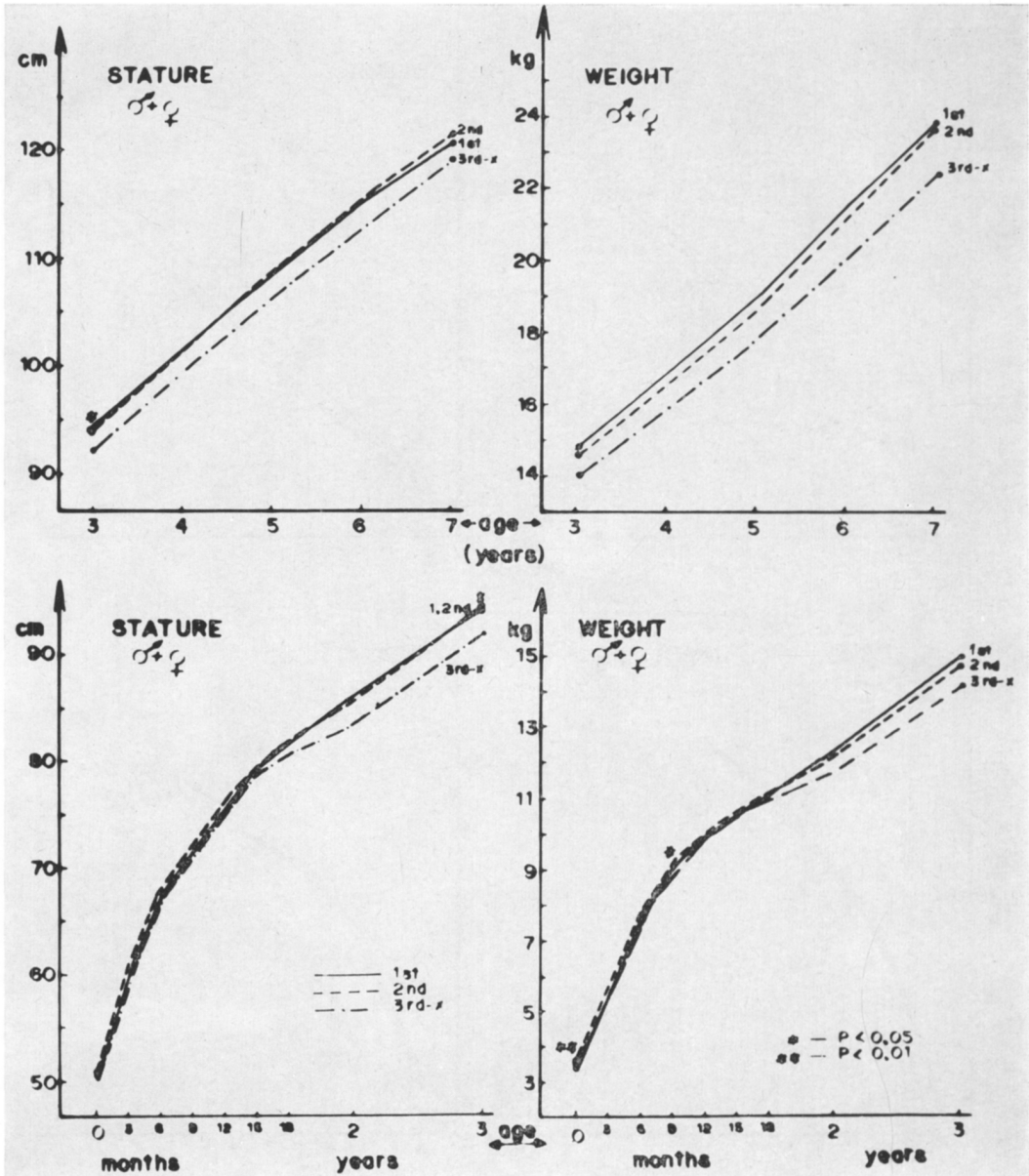


Fig. 9. Growth curves of stature and weight of children in relation to birth rank.

5. Height is influenced by parental mating type in the following ways:

- (a) the offspring of tall parents are the tallest and those of short ones the shortest;
- (b) the offspring of parents of different stature (heterologous groups) are taller than the children of parents of moderate stature;

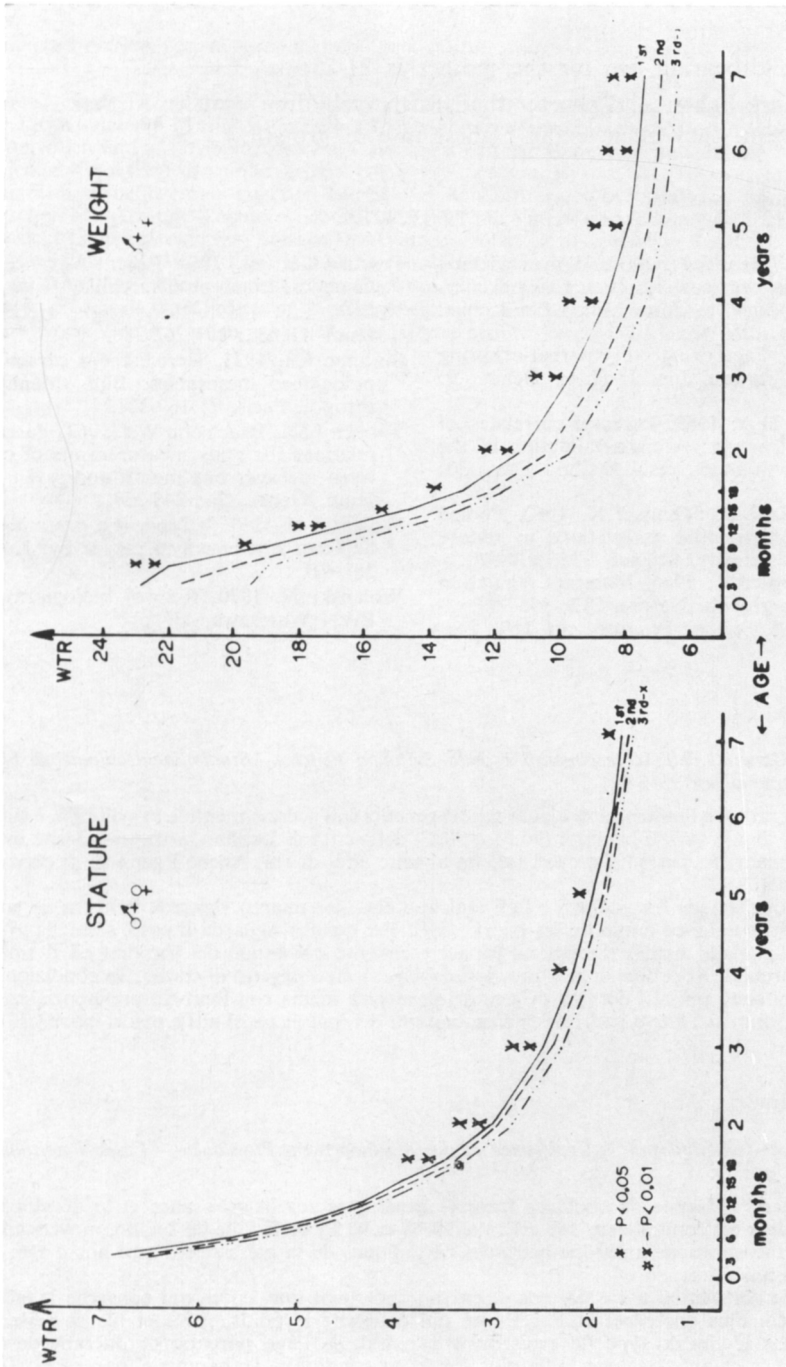


Fig. 10. Growth rate of stature and weight of children in relation to birth rank.

(c) children, especially daughters, of short fathers and tall mothers are taller than children of tall fathers and short mothers;

6. The best child-bearing age for the mother is 21-25;

7. First-borns are lighter and shorter than further children, but, in further stages of post-natal development, they achieve the highest rate of growth.

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#### RIASSUNTO

*Alcuni Problemi Genetici dell'Accrescimento e dello Sviluppo Fisico — Studio longitudinale su bambini dalla nascita ai sette anni di età*

Allo scopo di determinare l'influenza di alcuni fattori genetici sull'accrescimento e lo sviluppo, è stato condotto uno studio longitudinale su 180 bambini (90 M e 90 F) della città di Lublino, attraverso visite mediche e misurazioni antropometriche periodiche dalla nascita ai sette anni di età. Anche i genitori di ciascun bambino sono stati esaminati.

I coefficienti di correlazione fra genitori e figli indicano che, per quanto riguarda l'altezza, la somiglianza è maggiore fra madri e figlie ed è minore fra padri e figli. Per quanto riguarda il peso, somigliano più i figli ai padri che non le figlie alle madri. Il rapporto fra accrescimento e sviluppo dei bambini ed il tipo d'incrocio parentale, l'età parentale e l'ordine di genitura, sono anch'essi stati oggetto di studio. In condizioni di incrocio casuale, i bambini sono più alti dei figli di genitori di altezza media con incrocio preferenziale. I figli, e soprattutto le figlie, di madri alte e padri bassi crescono più dei figli di padri alti e madri basse.

#### RÉSUMÉ

*Quelques Problèmes Génétiques de la Croissance et du Développement Physique — Etude longitudinale sur des enfants de 0 à 7 ans*

Afin de déterminer l'influence de quelques facteurs génétiques sur la croissance et le développement, une étude longitudinale a été conduite sur 180 enfants (90 M et 90 F) de la ville de Lublin, moyennant des visites médicales et des mensurations anthropométriques périodiques de la naissance à sept ans d'âge. Les parents aussi ont été examinés.

Les coefficients de corrélation entre parents et enfants indiquent que, en ce qui concerne la taille, mères et filles se ressemblent plus que pères et fils. En ce qui concerne le poids, pères et fils se ressemblent plus que mères et filles. L'effet du type de croisement parental, de l'âge parental et du rang de naissance, a aussi été étudié. Les enfants ont une taille plus élevée en conditions de panmixie par rapport aux fils de parents de taille moyenne à croisement assortatif. Les fils, et surtout les filles de mères grandes et pères petits ont une taille plus élevée par rapport aux enfants de pères grands et mères petites.

## ZUSAMMENFASSUNG

*Einige Erblchkeitsprobleme von Körperwachstum und -Entwicklung — Längsschnittuntersuchung an Kindern von der Geburt bis zum Alter von 7 Jahren*

Um den Einfluß einiger Erbfaktoren auf Wachstum und Körperentwicklung festzustellen, wurden in der Stadt Lublin 180 Kinder (90 M und 90 W) einer Längsschnittuntersuchung unterzogen, die aus periodischen ärztlichen Kontrollen und anthropometrischen Messungen von der Geburt bis zu 7 Jahren bestand. Auch die Eltern eines jeden Kindes wurden untersucht.

Aus den Korrelationskoeffizienten zwischen Eltern und Kindern ergibt sich, daß die Ähnlichkeit der Körpergröße zwischen Müttern und Töchtern höher ist als zwischen Vätern und Söhnen, während die Ähnlichkeit im Körpergewicht hingegen zwischen Söhnen und Vätern größer ist als zwischen Töchtern und Müttern. Es wurde auch untersucht, ob Wachstum und Körperentwicklung in irgendeinem Verhältnis stehen zum Mischungstyp und Alter der Eltern oder zur Zeugungsfolge. Die Kinder mittelgroßer Eltern aus zufallsbedingter Mischung waren größer als die Kinder aus Vorzugsmischungen. Die Kinder, vor allem die Töchter, von großen Müttern und kleinen Vätern werden größer als die Kinder großer Väter und kleiner Mütter.

Dr. H.M. Chrzastek-Spruch, Pediatric Institute of Medical Academy, Staszica 11, 20-081 Lublin, Poland.