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GENETICS OF HUMAN DEVELOPMENT: ANTHROPOLOGICAL ASPECTS*)

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Anthropogenetics occupies an intermediate position between anthropology and genetics, using anthropological methods to solve genetic problems. Genetics of human development is at the border with that section of anthropology which sometimes is called pedanthropology (P o s p í š i l, 1965) or auxology (De T o n y, 1962) but for which, a broader name, age-related anthropology, seems more appropriate.

Among the many lines of human developmental genetics in which anthropology plays a substantial role, the following four are particularly important:

1. Study of the genetic preconditions of developmental acceleration.

2. Analysis of the effects of various parts of the genome on growth and development processes.

3. Analysis of the mechanism by which morphological and functional characters are inherited and linked with autosomes and sex chromosomes.

4. Evaluation of the role playd by heredity and environment in the establishment of structures and functions of the human body.

Let us consider in order the above four lines of study.

I

The analysis of acceleration attaches a decisive role to genetic factors. A century ago James G h e n t (1869), the founder of the London Anthropological Society, analysed the changes in the physical nature of inhabitants of North America compared with their European ancestors. His results are in striking agreement with those obtained in the last few years. The influx of immigrants from different European countries and the resulting broadening of the marital affinities that had formed in the Old World, seems to have been the main reason for the accelerated development of people in North America back in the 18th and early in the 19th century. It is difficult to believe that the observed changes in growth processes at that time could be in large measure due to environmental changes to which many authors tend to attach special importance. Two hundred ears ago there were no large cities in North America, and the nutrition of the immigrants appears to have been in keeping with the national standards. However, those were the years of formation of the American nation that has absorbed milions of immigrants of different ethnic origins. Although the proportion of international marriages had undoubtedly increased, the bulk of the families were made by persons of some one nationality. Yet, judging by immigrants of the Swiss origin (H u l s e, 1967) partners that formed families in the New World were, on average, more heterogenous genetically than their Old World ancestors.

The acceleration resulting from a mixing of the hitherto isolated parts of the population, is explained by the hypothesis of V. V. B u n a k (1968). However the reason for a slowing down of acceleration rates in certain population groups, for example, in the priviledged strata of North American whites (D a m o n, 1968) remains obscure, and it is not clear whether it is due to a narrowing of marital affinities or a further expansion of such affinities leads to decreased intensity of growth processes in the offspring. The second alternative seems more likely, since the improved communications, lifting of religious bans and constant immigration of the population are conducive to a progressive expansion rather than a narrowing of the range of marital affinities. We would like to propose here a hypothesis suggesting a certain average level of heterozygosity in the population as a precondition for developmental acceleration, assuming that the suboptimal and superoptimal levels of heterozygosity hinder acceleration. That suboptimal levels slow down acceleration is beyond doubt, since the children from marriages between closely related partners usually lag behind in their development (e.g. N e e l et al., 1968). As regards the superoptimal levels, the situation is uncertain, although N. Wolański's data (W o l a ń s k i et al., 1969) seems to suggest a slowing down of acceleration as well. With an increasing distance between the places of birth of parents, bodily dimensions of children within a given age group at first increase and then decrease. However, Wolański's results do not enable

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to ascertain whether this relationship is statistically significant; this author considered only the first phase of changes, i.e. increases of bodily dimensions.

Recognition of the role of genotypic changes in acceleration does not mean a denial of the role of environmental factors.

Our data on changes in the past hundred years in the body sizes of neonates and at the age of appearance of menses in girls in Moscow (N i k i t y u k, 1971, 1972), point to a deterioration of physical development and retardation of sexual maturation during World War Two, when nutrition of the population was inadequate. One should not therefore diminish the role of alimentary factors in acceleration. No less important appear to be the biological implications of urbanization. However, the susceptibility of the organism to environmental factors is determined by the genotype. This particularly refers to hereditary metabolic disorders when commonly used foods elicit metabolic disturbances and developmental retardation leading to mental retardation in the child. Thus, 0.005 % per cent of newborns (in the USA and Denmark) have been reported to show hereditary deficiency in galactose-I-phosphate uridyltransferase, an enzyme which blocks galactose metabolism. A timely exclusion of milk (galactose) from the diet and the use of hydrolyzed casein or soya bean protein as protein source, brings the child's development back to normal (H a n s e n , 1969). One may thus speak of changed growth activity as a result of the organism-environment conflict. An increase in heterozygosity enhances the body resistance to environmental influences (D u c r o s, 1970). This may explain the slowing down of growth processes when heterozygosity levels are above optimal.

II

Anthropological studies are important for assessing the ontogenesis-regulating effects of genes of various significance and of various "depth of occurrence". The latter term, which is not quite apposite from the genetic veiwpoint, but which nevertheless is highly illustrative, has been derived from the French anthropologist O l i v i e r (1964). Using the concept of Sutter, he represented the genome in the form of a water-filled vessel, and individual genes in the form of particles suspended in the water. In the deep layers of the liquid he placed the species-determining genes; in the superficial ones, the individual-determining gene; and in the intermediate ones, those genes responsible for ethnic origin and constitution. Those genes determining the physique, appear, we believe, to occur at a deeper level than those determining the species, for the extreme forms of body build — eurysomic and leptosomic, occur not only in man but also in many, if not all, mammals.

What, then, is the effect of various parts of the genome on growth and development processes?

We have established the relationships between the physique, and skeletal and sexual maturation in studies carried out jointly with L. E. Polushkina (N i k i t y u k and P o l u s h k i n a, 1972) in which 975 Tadjik and Uzbek girls and 1063 boys and adolescents 8—18 years have been examined in the city of Dushanbe. In this study, the development of secondary sex characters was recorded, and the growth of ossification centres and the degree of synostosis of epiphyseal zones were assessed on the basis of hand and foot X-ray films. The body build was evaluated on the basis of bodily proportions (as brachymorphic, mesomorphic, dolichomorphic) and the degree of fat deposition (as hypertrophic, mesotrophic, hypotrophic).

Comparison of individuals with the extreme forms of body build has shown that after that age of 13 to 14 brachymorphic and hypertrophic boys and girls exhibited an earlier maturation of hand and foot bones than dolichomorphic and hypotrophic ones. Similar differences have been noted in the degree of secondary sex characters. In children aged 8—9 years, the rate of skeletal maturation in the case of brachymorphy and hypertrophy, on the one hand, and in the case of dolichomorphy and hypotrophy, on the other, were the same or else dolichomorphic and hypotrophic children showed an earlier skeletal growth. Thus suggests a non-uniformity of gene actions on ontogenesis during different developmental periods.

The age between 13 and 18 years is the time of the establishment of generative functions and of the ordering of sex gland activity. The existence of well-defined correlations between body build and skeletal maturation during this period of life in contrast to rather ill-defined correlations between those characteristics during the time of hormonal rearrangements (the age of 8—9 years) serves to demonstrate the role of sex hormones as genetic inductors.

Thus, the genes determining human constitution, affect the ontogenetic rate, and this fits in into the concept of multiple effects produced by a given gene (pleiotropism). Moreover, it may be thought that it is rate of ontogenesis which is determined genetically, while the physique is determined by the former.

There is an extensive literature on the effects of ethnic origin on growth and development processes. It is held certain that children of a negroid show a faster development in the first months of life than those of an europeoid origin (T a n n e r, 1968. Such a conclusion has been reached from studies of children brought up under different socio-economic conditions, which as a rule were worse in case of negroid children. Possibly, this explains the above differences in ontogenetic rates in the first few months after birth. Subsequently, there occurs a levelling out of differences in pre-school age, followed even by a lagging behind in the physical development of negroid children.

We have compared the skeletal maturation of children within the europeoid race. The groups under comparison were from the rural population and had been brought up under essentially similar conditions. A few examples are given below.

We have compared the specific rates of periosteal bone formation and endosteal bone destruction in the hand, calculated from the results of longitudinal studies of Russian boys living in village Porechye in the Rostov region of the Yaroslavl' District and of Tadjik boys living in village Chorkoo of the Isfara region of the Leninabad District (Fig. 1). The rates of bone formation in both these groups increased from the ages of 9—12 to 12—15 years, showing a reduction by the age of 15—18. Specific rates of bone destruction in Tadjik boys change with age in the same way as in the Russian boys, i.e. decreased by the age of 12—15 years. In Russian boys aged 12—15, the specific rates of endosteal bone destruction were slower than at any other time considered, whereas in Tadjik boys they were highest.

Formation and destruction of osseous substance continues throughout the life cycle and does not stop at puberty. Comparison of adult Russian and Tadjik males and females from the same localities (i.e. Porechye and Chorkoo villages) has demonstrated differences in growth rates or individual bones of the hand. In Russians, these rates were highest in the distal phalanx, and in Tadjiks in the metacarpal bone (Fig. 2). All the subjects were rural inhabitants engaged in physical labour. Difference in the gradient of growth activity in hand bones cannot be accounted for by exogenous effects, and seem to be explained by genetic causes.

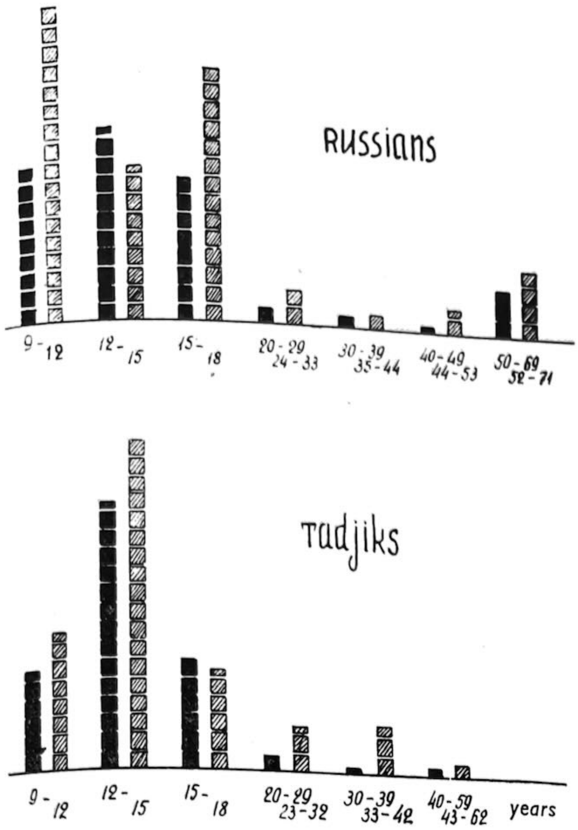

FIG. 1

Changes with the age of the specific rates of periosteal opposition (black) and endosteal resorption (shading) in the proximal phalanx of the middle finger. □ — 0,005 of specific rate.

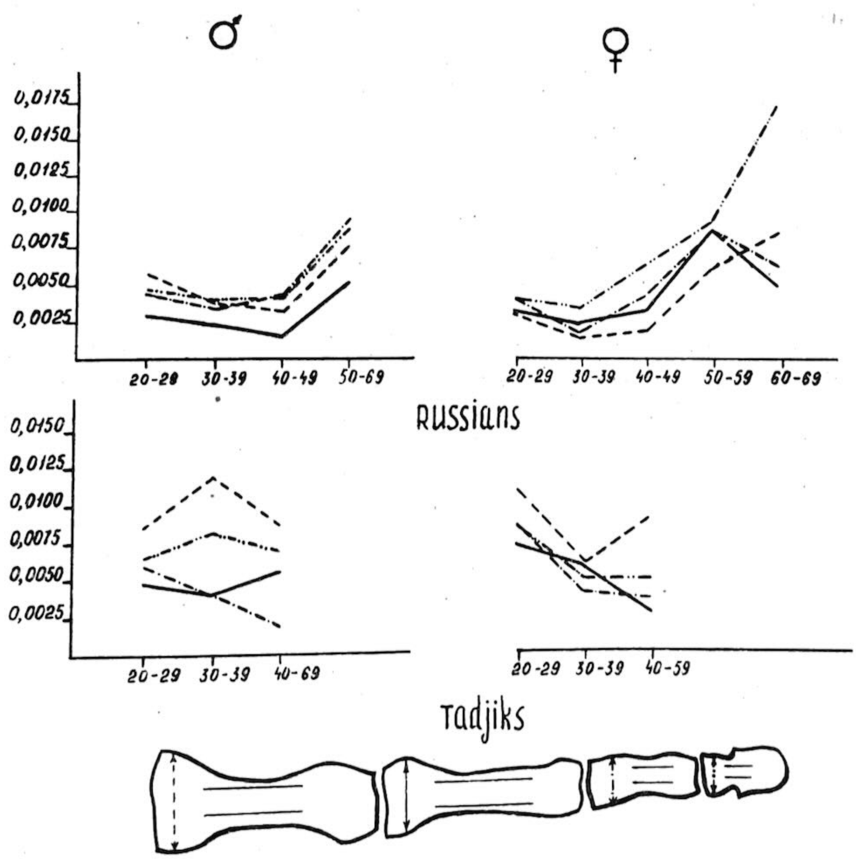

FIG. 2

Changes with the age of the specific rates of periosteal apposition in the bones of the middle finger.

III

Along with those genes responsible for the constitutional, species and ethnic features of man, there apparently exist genes common for members of a given family and determining the familial similarity. The latter is studied using correlation analysis (Bouchalová and Gerylová, 1970; Chesnis, 1971; and others). We have used this analysis to assess the correlation between the female body size (length of the body, interspinal and intercristal width of pelvis, and distance between the great trochanters and the anteroposterior outer size of pelvis) and of neonate body (length and weight of body, circumference of head, thorax and abdomen).

TABLE 1

Correlation coefficients between body size of women and of their newborn children

Correlation characteristic	Mother/son	Mother/daughter	p	Correlation characteristic	Mother/son	Mother/daughter	p
5/15	305 0.090 0.057	288 0.278 0.054		7/18	303 0.178 0.056	289–0.189 0.061	< 0.001
5/16	304 0.226 0.053	289 0.223 0.056		7/19	300 0.184 0.056	284 0.164 0.058	
5/17	305 0.151 0.056	291 0.060 0.058		8/15	301 0.321 0.052	287 0.191 0.057	< 0.1
5/18	305–0.206 0.060	291 0.187 0.057	< 0.001	8/16	300 0.238 0.054	288 0.192 0.057	
5/19	302 0.255 0.054	287 0.162 0.058		8/17	301 0.206 0.055	288 0.110 0.058	
6/15	304 0.182 0.056	288 0.226 0.056		8/18	301 0.242 0.054	289 0.157 0.057	
6/16	303 0.162 0.056	289 0.146 0.058		8/19	298 0.264 0.054	283 0.214 0.057	
6/17	304 0.129 0.056	290 0.008 0.059		12/15	297 0.290 0.053	275 0.176 0.058	
6/18	304 0.118 0.056	293 0.153 0.057		12/16	295 0.284 0.054	276 0.124 0.059	< 0.05
6/19	301 0.171 0.056	287 0.140 0.058		12/17	297 0.176 0.057	280 0.075 0.059	
7/15	303 0.297 0.052	287 0.150 0.058	< 0.1	12/18	297 0.253 0.054	278 0.158 0.058	
7/16	302 0.214 0.055	288 0.143 0.058		12/19	294 0.307 0.053	278 0.075 0.060	< 0.01
7/17	303 0.166 0.056	289–0.085 0.058	< 0.002				

Notes: 5—12 — dimensions of maternal body: 5 — interspinal width of pelvis; 6 — intercristal width of pelvis; 7 — intertrochanteric width of thighs; 8 — outer straight diameter of pelvis; 12 — body length. 15—19 — dimensions of child body: 15 — body length; 16 — weight; 17 — circumference of head; 18 — circumference of thorax 19 — circumference of abdomen.

TABLE 2

Correlation coefficients for body length of parents and children (M. I. Rubinov's data)

Pair	Child age (years)					
	Russians		Germans		Tartars	
	6	7	6	7	6	7
Father/son	0.46 ± 0.10	0.53 ± 0.10	0.41 ± 0.18	0.47 ± 0.17	0.42 ± 0.19	0.46 ± 0.16
Mother/daughter	0.43 ± 0.10	0.51 ± 0.13	0.49 ± 0.16	0.55 ± 0.13	0.41 ± 0.18	0.49 ± 0.15
Father/daughter	0.15 ± 0.13	0.33 ± 0.14	0.31 ± 0.19	0.36 ± 0.16	0.31 ± 0.21	0.37 ± 0.17
Mother/son	0.27 ± 0.21	0.34 ± 0.13	0.39 ± 0.19	0.44 ± 0.18	0.33 ± 0.21	0.39 ± 0.17

Out of twenty five correlation coefficients calculated separately for mother-son and mother-daughter pairs, the correlation in mother-son pairs was higher in twenty cases (Table I). These results differ from the conclusion made by G. Chesnis (1971) that the sex of children and parents has no effect on the degree of similarity between them. However, the non-uniformity of correlation established by us, appears to decrease with the child's age. After the age of 1 year, the correlation in mother-son and mother-daughter pairs becomes approximately the same (Bouchalová and Gerylová, 1970). In pre-school age and early in school age, the morphological similarity of father with son and of mother with daughter is greater in each of the three ethnic groups than the similarity of father with daughter and of mother with son, according to the data of our specialist M. I. Rubinov (Table 2).

Thus, the intensity of correlation in the body size of parents and their children varies with child's age. In the neonatal period, the correlation between son and mother is greater than that between daughter and mother. Conversely, by the age of 6—7 years, daughter becomes more similar to mother than son. While the greater similarity between the parents and their children aged 6—7 years may be explained by the action of sex hormones, the greater similarity of mother with her neonatal son (not daughter) appears to by accounted for by genetic causes.

Lately, an opinion has been expressed that the genes responsible for certain morphological features of the skeleton and dental system are linked with the sex X-chromosome. The well known American anthropogenetist, osteologist and odontologist Stanley Garn has come to this conclusion because the correlation among sibs in sister/sister pairs is higher than in brother brother/sister sister pairs. According to Garn and his co-workers (Garn, Hertzog gand Rohmann, 1969) this is manifested in the correlation of the length of body and leg. Sisters-sibs more closely resemble each other in the time of dental development than brothers (Garn, Lewis and Polacheck, 1960). These results together with the supposed "dose effect" in skeletal ossification and the denial of Lyon's hypothesis (Lyon, 1966) on inactivation in females of one of two X-chromosomes (Garn, McCreery, 1970) has led to the conclusion that some morphological features are linked with the X-chromosome (Garn et al., 1969, 1970).

We have checked both these Garn's hypotheses. One drawback of the work of this author consists in the fact that sibs of different ages were compared. So we have calculated coefficients of intra-class correlation between body lengths of neonatal twin boys, girls and mixed pairs. Such coefficients have also been calculated for body weight (Table 3).

The correlation in the sister/sister pairs was greater than in brother/brother pairs for body length and smaller for body weight, although these differences in correlation coefficient were insignificant statistically.

TABLE 3

Correlation coefficients for body length and weight in neonatal twins

Correlation characteristic		Correlated sibs		
		brother/brother	sister/sister	brother/sister
Body length	N	156	190	136
	r	0.608	0.690	0.643
	m(r)	±0.050	±0.038	±0.050
Body weight	N	158	194	140
	r	0.655	0.574	0.520
	m(r)	±0.045	±0.048	±0.062

Note: in the calculations, mono- and dizygotic sibs were pooled.

Let us now discuss the second Garn's hypothesis. In the higher variability of skeletal ossification times in girls he saw a manifestation of the dose effect, thus placing in doubt the hypothesis on inactivation of one of the X-chromosomes in females. Using the data available in the literature, we have compared variation coefficients for a number of morphological characters in children of different ages in relation with their sex (Table 4).

TABLE 4

Sex differences in variation coefficients

Author	Age	Ethnic group	Total number of correlations	Coefficient greater in girls
R. Novruzov (1970)	Neonatal	Turkmens	12	6
Enăchesku and	Neonatal	Roumanians	36	7
Pop (1956, 1956a)	Neonatal	Roumanians	35	7
K. Sh. Abdurashitova and A. P. Letanina (1963)	Neonatal	Russians Tartars Bashkirians	4	3
I. A. Biriukov (1965, 1965a)	Neonatal	Nenets	4	1
		Mansis	4	1
B. A. Asanbaeva (1962)	Neonatal	Kirghizs Russians	8	0
Sinnett (1961)	Neonatal	Australian europeoids	9	2
		Total	112	27
V. A. Grishina (1967)	Ist year	Not indicated (Chita)	52	17
Y. Stankus and S. Pavilomis (1968)	Ist year	Lithuanians	52	40
		Total	104	57

Variability of characters in girls was not found to be greater than in boys; on the contrary, some neonatal boys showed higher variation coefficeents. Sex differences in the degrees of variability may suggest not a kind of genetic regulation in different sexes but rather a different intensity of growth. An increase in growth intensity increases the variability of morphological characters (U r y s o n, 1962; K o n c h a, 1967). However, while casting doubt on the validity of the method adopted by Garn, to prove the activity of both X-chromosomes in females, we do not deny the idea on the genetic significance of both these chromosomes in females.

The son inherits from the parents X- and Y-chromosomes and is heterozygotic in sex chromosomes. The daughter, having two X-chromosomes, is homozygotic in them. X- and Y-chromosomes carry different genes over most of their length, only small areas being homologous. Therefore whatever genes a son received from his mother with the X-chromosomes, they will inevitably show their effect, since the other allele is absent. In order that the same morphological character was present in a daughter, it should possess a dominant action, for it is opposed by the other allele. If the intensity of correlation in mother-son pairs is higher than in mother-daughter pairs, this suggests a linking of genes of morphological characters with that part of the X-chromosome which is devoid of homologue in the Y-chromosome. Our hypothesis does not contradict the concept of Lyons, for it does recognizes the activity of both X-chromosomes in the first two weeks of embryonal development (S w a n s o n, M e r z and Y o u n g, 1969). It may be thought that this time is sufficient for the formation of those features in the embryo which later determine a greater similarity of mother with her neonatal son than with her neonatal daughter.

IV

Anthropological data play a great role in evaluating the importance of inherited and acquired characters under environmental effects during ontogeny. The twin method used for this purpose is useful for genetics, but its proper use required anthropological knowledge.

We have employed this method in studying the body build and skeletal maturation in Moscow preschool and school children aged from 5 to 15 years. 69 female, 66 male and 21 mixed twin pairs have been studied, a total of 156 pairs. The degree of twin identity was determined from the principle of similarity, taking into account such morphological characters as the colour and form of hair, the colour of skin and iris, and form of soft parts of the face. Hand impressions were made to assess the appearance of the finger pattern for the ten fingers of both hands, and also the total ridge count, and sites of termination of main palmar lines and palmar patterns. The degree of twin identity was also evaluated from the pattern of the occlucal surface of molars and premolars (odontoglyphics). In establishing the diagnosis, the characteristics given to the twins by their mother were also taken into account along with physiological, dermatoglyphic and odontoglyphic features. As a result of this analysis, 35 male and 37 female pairs were identified as monozygotic and 31 male and 32 female pairs as dizygotic.

All the subjects were subjected to roentgenography of the right elbow joint and of the right and left hands. On hand X-ray films, the dimensions of the right and left proximal and distal phalanges of the third finger (length, diameter of base, head, diaphysis and bone marrow cavity) were measured with a slide-gage with an accuracy of 0.1 mm. On X-ray films of elbow joint the thickness of subcutaneous fat and muscles was measured on the medial and lateral sides of the arm in its lower third and of the forearm in the upper third. The number of ossification centres was determined in the wrist. Coefficients of intra-class correlation were calculated. Heritability index (H) was calculated according Holtzinger's formula. This index $\left(H = \frac{r_{mt} - r_{ht}}{1 - r_{ht}}\right)$, where r_{mt} and r_{ht} are coefficients of intra-class correlation for monozygous and heterozygous twins) conventionally characterizes the share of endogenous effects on the character studied. We well realize the conventionality of Holtzinger's formula, as well as of other formulas proposed to assess the degree of endogenous effects. We were interested in local manifestations of such effects on various morphological characters. For these purposes, any formula is suitable, provided it is used in a uniform manner in all the cases under study.

Our calculations for the proximal phalanx of the middle finger of the right hand have shown that, as a rule, the correlation coefficient in monozygous twins exceeds 0.9 and in heterozygous twins 0.5 to 0.6 (Table 5). Holtzinger's coefficients were very similar for all the dimensions studied, and constituted in boys and adolescents 0,54 for the phalanx length and 0.78—0.86 for phalanx diameter (Fig. 3). Among females, inheritability coefficients were lower: 0.76 for phalanx length and 0.12—0.55 for other dimensions of phalanx.

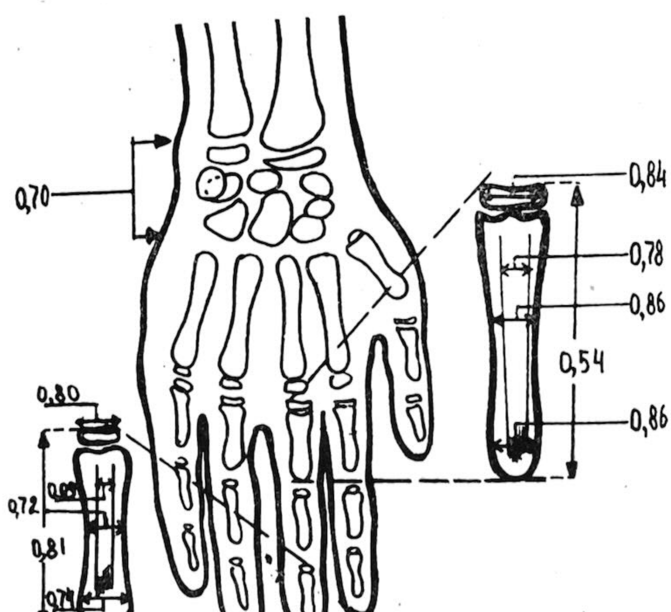

FIG. 3
Holtzinger's coefficients for the different dimensions of the hand in russian boys and adolescents.

In the distal phalanx of both sexes, the correlation coefficients were generally lower than in case of respective dimensions of the proximal phalanx. Thus, in monozygous twin boys and adolescents, the correlation coefficient for the diameter of bone marrow cavity was 0.556 ± 0.093 for the distal phalanx of the left hand and 0.809 ± 0.046 for the proximal phalanx (Table 5). For the diameter of phalanx head, the correlation coefficient was lower than for its base: 0.033 ± 0.119 against 0.774 ± ± 0.054 for the distal phalanx of the left hand in heterozygous twin boys (Table 5. For the diameter of phalanx diaphysis, correlation coefficients were lower in all groups divided into sexes and the character of zygocity, than for the diameter of phalanx basis. In most sex-zygous groups correlation coefficients for the diameter of the phalanx diaphysis were lower than for the diameter of the head.

Holtzinger's indexes were lower for the distal phalanx than for the respective dimensions of the proximal phalanx, excepting the length of the distal phalanx of the right hand where Holtzinger's index was 0.81 against 0.54 for the length of the proximal phalanx of the same hand (Table 5).

For soft tissues of the arm and forearm (subcutaneous fat and muscle coats), correlation coefficients in the monozygous and dizygous twin groups were lower than for the hand bones or humerus in the same groups. Holtzinger's indexes were also lower (0.15—0.57 for males). This seems to suggest a lesser degree of endogenous influences on the development of soft tissues of the hand compared

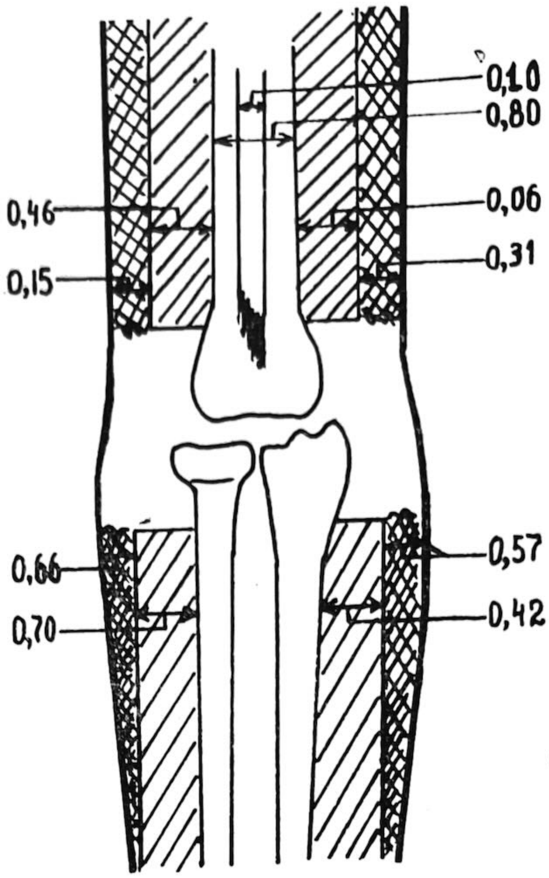

FIG. 4
Holtzinger's coefficients for the different dimensions of the soft tissues of the arm and of the forearm in russian boys and adolescents.

TABLE 5
Correlation coefficients and Holtzinger's indexes (H) calculated for hand bones of boys and adolescents aged 5—15

Characteristic	Right hand			Left hand		
	$Nr_{mt} \pm m(\eta_{mt})$	$Nr_{ht} \pm m(\eta_{ht})$	H	$Nr_{mt} \pm m(\eta_{mt})$	$Nr_{ht} \pm m(\eta_{ht})$	H
Length of distal phalanx	60 0.967 ± 0.011	56 0.828 ± 0.042	0.81	62 0.917 ± 0.020	52 0.864 ± 0.035	0.39
Width of base dist. phal.	58 0.958 ± 0.011	56 0.790 ± 0.051	0.80	60 0.950 ± 0.013	56 0.774 ± 0.054	0.78
Width of head dist. phal.	58 0.840 ± 0.039	56 0.371 ± 0.116	0.74	60 0.868 ± 0.032	52 0.388 ± 0.119	0.78
Width of diaphysis dist. phal.	58 0.881 ± 0.029	56 0.570 ± 0.091	0.72	60 0.816 ± 0.043	60 0.533 ± 0.098	0.61
Width of bone marrow cavity dist. phal.	54 0.699 ± 0.070	54 0.669 ± 0.091	0.09	56 0.556 ± 0.093	52 0.516 ± 0.103	0.08
Length of proximal phalanx	56 0.917 ± 0.022	60 0.818 ± 0.043	0.54	62 0.931 ± 0.017	60 0.862 ± 0.033	0.50
Width of base prox. phal.	58 0.976 ± 0.006	60 0.852 ± 0.036	0.84	62 0.986 ± 0.004	60 0.844 ± 0.037	0.91
Width of head prox. phal.	60 0.937 ± 0.016	60 0.554 ± 0.090	0.86	62 0.934 ± 0.016	60 0.606 ± 0.082	0.83
Width of diaphysis prox. phal.	60 0.958 ± 0.011	60 0.695 ± 0.067	0.86	62 0.888 ± 0.027	60 0.682 ± 0.069	0.65
Width of bone marrow cavity prox. phal.	58 0.920 ± 0.020	60 0.634 ± 0.078	0.78	58 0.809 ± 0.046	60 0.478 ± 0.100	0.63

with its bony base. Local differences are interesting: the index was higher for subcutaneous fat and muscles of the fore arm than for soft tissues of the arm (Fig. 4).

The twin method is far from being perfect, although it was proposed by Francis Halton about a century ago. The mathematical apparatus of this method needs revision. The use of different formulas to the same initial data may frequently lead to contradictory results. Prospects of this method were forecast by S. G. Levit forty years ago (1934) in an introductory article to the 3rd volume of Proccedings of the Gorky Medico-biological institute They consist in studying twins of different ages, different ethnic origins and under different environments. It may be thought that the proportion of endogenous influences on the development of morphological and functional characters in the above categories of subjects is unequal. It should be added to this that the characters in the groups under study should be covered as widely as possible, since the endogenous effects are manifested in the development of different morphological characters in different ways.

What is the practical value of evaluating the role of heredity and environment in the development of a child, performed in the course of time-consuming twin studies? An answer to this question was given by M. V. Ignatiev, one of the best anthropogenetists of our time (1937). The end purpose of scientific work in the field is to select environmental conditions most favourable for the realization of all positive features of a given genotype. When there is a certain hereditary trouble with some organ or system, environmental effects should prevent the development of a pathological characteristic. To carry out this task, data should be accumulated on the interactions between the environment and the body, on the development of the organism with certain genetic predispositions under different environmental conditions. An invaluable contribution to solving this question may be the study of rare cases of separate education of monozygous twins. However, this may be artificially reproduced in special closed educational establishments specially designed for twins. That such establishments may be useful from the scientific point of view, is suggested by the experience gained by the Medico-genetic institute of Moscow. It may be thought that education in special medico-pedagogical establishment would be advantageous for twins as well. It should not be forgotten that they not infrequently lag behind in their development and need special attention on the part of teachers and physicians, which is difficult to provide at home. The control of development of these children may be greatly facilitated by anthropometric methods which are widely used by hygienists.

To conclude, none of the considered aspects of human developmental genetics can be elucidated unless anthropological methods and techniques are used. A success in anthropogenetics is impossible without the development of a number of fields of modern anthropology, including ethnic anthropology.

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