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SEXUAL DIMORPHISM IN HUMAN FOETAL DEVELOPMENT

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Abstract: *This paper is part of our research on intersexual differeences in human foetal development. The differences in the development of somatic features and the weight of internal foetal organs have been investigated. Also, an effort has been made to identify the effect of main environmental factors on the development of individuals of sex either. Data of 2000 foetuses stillborn at the conceptional age from 20 to 44 weeks have been analysed. The formation of somatic features have been statistically analysed in terms of factors commonly recognised as risk factors: maternal age, parity, the number of induced and spontaneous abortions. The normalised biometric profiles have made possible to assess graphically the degree of sexual differences of all features investigated in a given age group. Our results show that all features investigated are genetically more determined in female than in male foetuses. Female foetuses have better defense properties against the damaging effect of invironmental factors.*
Key words: *Foetal development; Sexual dimorphism.*

Introduction

Sexual dimorphism, i.e. bidirectional formation connected with the individual's sex, manifests itself in morphological, physiological, motoric, mental, and other features. The differences resulting from it are genetically determined.

Chromosomes *X* and *Y* play a secondary role in determining body measurements and the distribution of the adipose and muscular tissue because the process is controlled by hormones whose level and activity are a reesult of influences of many genes and environmental factors. Although the basic differences in the dimorphism of body structure and function are the same in all human, a lot of details may depend on secondary factors, biological and social.

The stage character of intensification and slow disappearance of dimorphic differences in the postnatal development has thoroughly been studied whereas the problem of sexual dimorphism during the period of foetal development has reraly been considered and the results are often equivocal or inconsistent.

Tanimura et al. (1970) state that sexual differences of the weight of the foetal body and inner organs are slight and unimportant. According to Tanner, by the end of the foetal period dimorphic differences related to length and other linear dimensions range from 1% to 3%, and amount to about 4% if related to body weight.

The studies of the Polish population carried out by Slomko & Kuczynski (1969) and Brzozowska (1972) confirmed the occurrence of sexual differentiation in the final stage of foetal life and its influence on all observed measurements, i.e. body weight, lenght and head circumference. Some subtle differences in the degree of formation of some of the features in favour of either sex were also observed by Marecki (1980). However, it was impossible to determine the sequence of the discriminating features.

This paper is a part of a wider research on human foetal development and attempts to present a reliable analysis of dimorphic differences of somatic features and the weight of the inner organs during intrauterine development.

An attempt to identify the influence of various non-genetic risk factors on the development of individuals of both sexes was also made.

Table 1. Statistical characteristics of female foetuses

Months	V		VI		VII		VIII		IX		X		XI	
Feature	N = 23		N = 152		N = 175		N = 165		N = 111		N = 96		N = 26	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Crown-heel length	29.0	3.3	30.4	3.4	36.2	3.9	41.0	4.0	43.9	5.3	49.1	4.9	51.6	3.1
Crown-rump length	19.2	2.2	20.3	2.5	24.1	2.5	27.5	3.2	29.4	4.2	32.9	3.5	34.4	2.9
Body weight	509.1	207.6	559.5	179.7	339.1	304.9	1482.3	424.5	1956.6	654.2	2655.0	706.0	3136.3	548.6
Circumference of:														
– head	20.5	3.6	21.0	3.8	24.5	2.4	28.0	2.7	30.4	3.6	32.6	3.1	33.5	2.6
– shoulders	18.6	1.5	19.7	2.1	23.4	3.0	27.5	3.1	30.4	4.2	33.6	4.3	35.3	3.4
– chest	17.2	2.2	17.8	2.0	21.1	2.6	24.9	2.4	27.6	3.5	30.2	3.4	32.5	2.7
– abdomen	15.8	2.8	16.1	2.2	19.2	3.0	23.5	3.2	26.2	4.3	28.7	4.1	29.6	2.4
Weight of:														
– brain	65.1	19.4	76.6	26.0	126.3	37.9	186.4	48.3	237.9	72.3	314.5	91.0	378.3	61.4
– heart	4.5	2.0	5.2	4.9	7.7	3.1	12.4	4.8	16.0	6.7	20.9	8.0	23.0	5.5
– lungs	6.3	2.5	7.3	2.7	12.7	5.9	19.4	7.7	21.3	10.1	25.9	10.7	25.8	6.8
– liver	29.9	10.2	34.0	12.1	50.4	17.4	74.7	30.6	95.1	45.0	120.7	53.8	141.9	53.3
– spleen	1.3	1.1	1.2	0.8	2.7	2.1	5.0	4.4	7.2	5.0	10.4	6.9	10.3	4.5
– kidneys	2.2	1.0	2.9	1.2	4.8	2.4	7.5	3.4	9.5	4.5	12.1	4.9	13.5	3.8
– suprarenal gl.	1.8	0.7	2.5	1.1	3.5	1.4	4.4	1.7	5.2	3.3	7.6	4.2	8.0	3.7
– thymus	1.1	0.8	1.6	1.0	2.8	1.6	4.5	2.8	6.6	4.7	7.9	5.0	8.4	5.0

Table 2. Statistical characteristics of male foetuses

Months	V		VI		VII		VIII		IX		X		XI	
Feature	N = 47		N = 189		N = 259		N = 292		N = 189		N = 108		N = 26	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Crown-heel length	28.3	3.3	31.2	3.8	36.9	3.8	41.9	3.8	46.3	3.6	50.2	4.8	51.9	3.6
Crown-rump length	18.6	2.4	20.8	2.8	24.7	2.7	28.1	3.1	31.1	3.1	33.4	3.4	33.9	3.1
Body weight	427.1	159.1	619.4	247.9	1053.8	357.1	1595.5	450.9	2194.2	593.0	2797.0	772.2	3150.5	795.3
Circumference of:														
– head	19.0	2.3	21.4	2.6	25.4	2.5	28.8	2.7	31.2	2.7	33.7	3.5	33.3	3.0
– shoulders	18.3	2.0	20.2	2.7	24.3	2.9	28.0	3.4	31.4	3.7	34.2	4.3	34.3	3.4
– chest	16.4	1.8	18.1	2.5	21.7	2.8	25.3	2.9	28.4	3.1	30.5	3.4	32.2	3.5
– abdomen	14.8	2.0	16.6	2.7	19.7	2.9	23.4	3.3	26.8	3.8	29.2	3.8	29.9	3.6
Weight of:														
– brain	60.0	21.1	82.6	30.2	138.0	40.5	202.2	49.5	269.0	54.7	344.1	75.2	363.6	95.5
– heart	3.7	2.1	5.2	2.3	8.4	3.5	12.8	4.7	17.7	6.7	22.0	6.5	23.8	8.0
– lungs	6.3	2.2	8.2	3.7	13.8	5.8	19.7	7.3	24.3	8.5	28.8	11.9	29.2	10.5
– liver	24.6	10.7	34.9	13.6	53.6	18.0	74.3	29.5	102.7	44.9	126.2	47.9	134.6	53.0
– spleen	1.0	0.7	1.4	1.1	2.8	2.0	56.	3.8	9.8	6.7	10.7	6.6	14.7	17.8
– kidneys	2.3	1.1	3.4	1.8	5.5	2.6	8.4	3.3	11.3	4.4	14.5	5.4	15.0	4.6
– suprarenal gl.	1.9	1.0	2.9	1.2	3.8	1.6	4.8	1.9	6.6	3.6	8.2	4.0	7.7	3.8
– thymus	1.1	0.7	1.8	1.3	3.2	1.8	5.4	3.5	7.5	4.8	8.8	5.5	10.9	5.3

Material and Methods

The research material comprising 1858 foetuses stillborn between the 20th and 44th week of pregnancy was collected in the Department of Obstetrics and Gynaecology at the University of Medical Sciences, Poznan. On the basis of clinical diagnosis and selection of the material, individuals with symptoms of autolysis, maceration and dystrophy, with congenital anomaly and mechanical body injuries were excluded from the analysis. The data was analysed in seven, monthly developmental groups, from the 5th to the 11th month of foetal life. The statistical analysis was carried out on the process of formation of somatic features and the weight of foetal inner organs in various risk factor categories: maternal age, parity, the number of induced and spontaneous abortions of the mother.

Results

The general statistical analysis concerned the development of body weight, overall length, crown-rump length, circumference of the head, chest and abdomen, and the weight of the following organs: brain, heart, lungs, liver, spleen, kidneys, adrenal glands and thymus, see *Tables 1* and *2*.

The above mentioned statistical characteristics show that dimorphic differences occur in all developmental periods studied although with different intensity.

Moreover, for all these features, dimorphic differences are significant on the level $\alpha = 0.01$ between the 5th and 10th month. The occurrence of developmental differences between male and female foetuses proved the necessity of a more objective study of this phenomenon by means of a common scale of reference for both sexes. Such a comparison was made on the basis of the normalised biometrical profiles calculated according to the formula:

$$\frac{\bar{x}_{♂} - \bar{x}_{♀}}{s_{♂}},$$

where $\bar{x}_{♂}$ = arithmetic average of the value of male foetal meature,
$\bar{x}_{♀}$ = arithmetic average of the value of female foetal feature, and
$s_{♂}$ = standard deviation of male foetal feature.

The profiles constructed in this way allow for an evaluation of the degree of dimorphic differences of all features simultaneously in a given age group.

Female foetal features situated on the profile over the arithmetic average of male foetuses have higher values during that period, and those below the male average are smaller. The differences become more obvious right before delivery (*Figures 1, 2* and *3*). Dimorphic differences in foetal development manifest themselves also in a different degree of vulnerability of male and female foetuses to the influence of risk factors. This was proved by the results of the *Q* index calculated separately for both sexes.

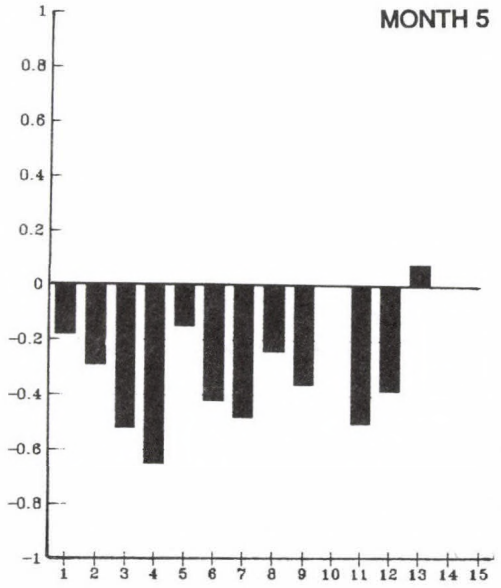

Fig. 1

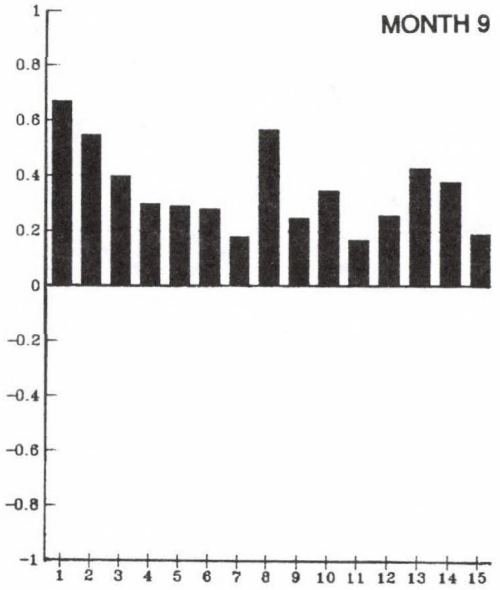

Fig. 2

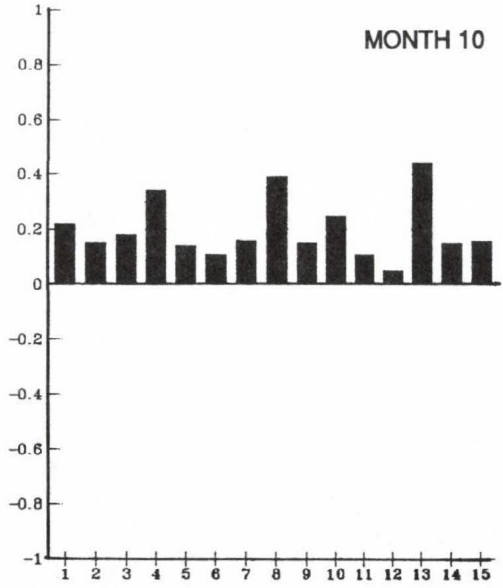

Fig. 3

Fig. 1: Dimorphic differences in some body measurements and organs in the 5th foetal month 1 – Crown-heel length; 2 – Crown-rump length; 3 – Body weight; 4 – Circumference of the head; 5 – Circumference of the shoulders; 6 – Circumference of the chest; 7 – Circumference of the abdomen; 8 – Weight of the brain; 9 – Weight of the heart; 10 – Weight of the lungs; 11 – Weight of the liver; 12 – Weight of the spleen; 13 – Weight of the kidneys; 14 – Weight of suprarenal glands; 15 – Weight of the thymus

Fig. 2: Dimorphic differences in some body measurements and organs in the 9th foetal month (for the features, see Fig. 1)

Fig. 3: Dimorphic differences in some body measurements and organs in the 10th foetal month (for features, see Fig. 1)

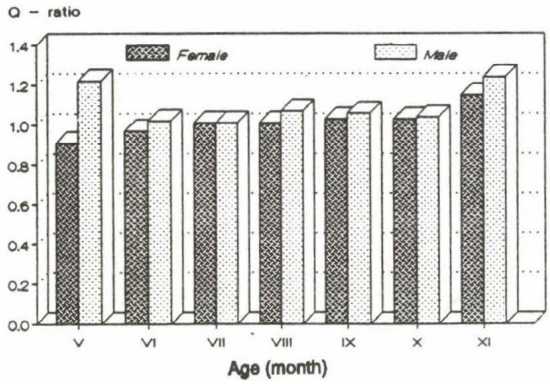

Fig. 4: Intersexual comparison of variability of Q-ratio in no-risk/at risk groups in fifth–eleventh month in the foetal life

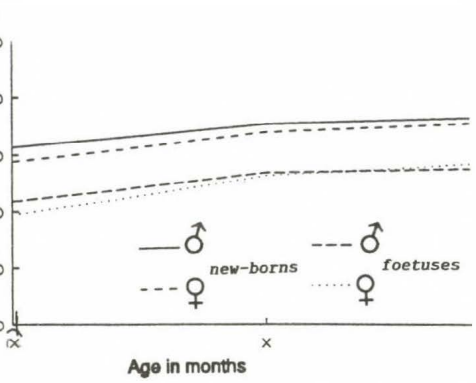

Fig. 5: Intersexual differences in body mass in new-borns and foetuses in ninth–eleventh month of foetal life

Q_i (i = 1 . . . p) are quotients of values of the studied features (p) in both groups (risk and non-risk) in the consecutive months of development. Taking into consideration the coefficients Q_i calculated in this way, the total (global) index was calculated:

$$Q = \frac{\sum_{i=1}^{p} Q_i}{p}$$

Figure 4 shows the intersexual comparison of variability of these coefficients in the course of foetal life.

On the basis of these results it can be generally stated that sexual dimorphism of somatic features and the weight of foetal inner organs is only weakly expressed. However, some small differences in the degree of formation of some of the features in favour of either sex can already be observed in this period. In the majority of features studied, intersexual differences show a trend to attain higher values in the male sex. Some differences between the sexes manifesting themselves also in a different degree of vulnerability to the influence of maternal factors were noticed in the material studied, too.

The studies of the complex influence of maternal factors on foetal development carried out by comparing average values of somatic features and the inner organs weight between the group at risk versus without risk show the lack of significant differences in the development of the discussed features in female foetuses up to the 10th month of foetal life. Only in the 11th month all these features have higher values in the non-risk group. In male foetuses all the features have higher values in the studied period of foetal ontogenesis in the non-risk group and the statistically significant differences occur in the 5th, 8th and 9th month of life. In order to give a better picture of the decrease of value of the features occuring in the final stage of foetal ontogenesis, intersexual differences in the development of body mass in newborns and foetuses at risk were compared (*Fig. 5*).

Male newborns have higher valuees of body mass than female newborns and the difference is the biggest in the 9th month, i.e. in the perinatal period.

Dimorphic differences are smaller in foetuses when compared with newborn babies, and female foetuses reach slightly higher values than the males in the 9th month. This is probably caused by the fact that the foetuses studied belonged to the group at risk. Male foetuses exhibited increased vulnerability to risk factors decreasing the body mass value, especially in the 11th month of pregnancy.

The reults show a complex effect of maternal factors on foetal development, but only in the final stage of foetal ontogenesis, and indicate increased resistance of female foetuses. Genetic determination of the features studied is much more expressed in female foetuses better "equipped" to counteract the harmful influence of non-genetic factors.

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