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Sexual dimorphism of the organism's response (fluctuating asymmetry level) to environmental stress

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Analysis of eight cephalometric paired characters of 651 boys and 585 girls aged 7 to 10 years was carried out. The standardised variance of differences between right and left character values (R-L) were used to assess the fluctuating asymmetry (FA) level of each character. The highest values of FA were observed for the width of the wings of the nose (ala) (*al-sn*) and for the length of the nostrils (*na-np*), and the lowest for the length of the auricle (*sa-sba*) and the length of the mandibular body (*go-gn*). Using the multiple regression, associations between the FA of the head and selected prenatal factors were estimated. All fourteen prenatal factors taken together explain on average about 7% (in case of boys) and below 3% (in case of girls) of the FA variability analysed. Among the prenatal factors, declared alcohol consumption by mother and tobacco smoking by father increased the head FA level of both boys and girls. Additionally, in case of boys, trauma increased the FA level of the auricle and nose region.

Key words: fluctuating asymmetry, developmental instability, cephalometric structures

INTRODUCTION

Fluctuating asymmetry (FA) level is considered to be the developing organism's answer to environmental stress. The FA level depends on many factors such as the kind, intensity and duration of the stressor, the ability of an individual to stabilise development in adverse conditions (1, 2). It is known that boys' and girls' organisms are characterised by different reactions to environmental disturbances. The difference lies in the fact that females (with two X chromosomes) respond to developmental stress more slowly and with a lower intensity, but, on the other hand, strong, long-lasting disorders seem to disturb their developmental path more permanently.

To analyse the organism's response to different environmental factors, the cephalometric structures characterising non-directional asymmetry (FA) were chosen. These paired morphological face structures (nostrils, ears, eyes, mandibular body) reach their final shape scheme and the final position in the head during the 16th week of fetal life.

The aim of this work was assessment of a relation between selected prenatal factors that affect the developing organism and the level of fluctuating asymmetry of paired structures of the boy's and girl's face.

MATERIALS AND METHODS

Material was collected in 2002 / 2003 by periodically monitoring the physical development of children piloted by the Chair of Anthropology of the Lodz University. The studies involved 651 boys and 585 girls from primary schools in Lodz (Poland), grades 1 to 3, aged 7 to 10 years. The following paired cephalometric characters were investigated: mandibular body length (*go-gn*), eye fissure length (*en-ex*), auricle length (*sa-sba*), the width of the auricle (*pra-pa*), the width of the ear insertion to the head (*obs-obi*), the width of the nostril base (*ac-sn*), the width of the ala (*al-sn*) and the length of the nostrils (*na-np*) (Fig.1). All the paired head measurements were taken by the author according to Farkas' (15) procedure using a sliding or spreading calliper. The information concerning prenatal factors was derived from questionnaires filled in by parents. The birth characteristics were completed using the child's health book. An organism's response to environmental stress was measured as a fluctuating asymmetry level (FA) of paired cephalometric structures. FA was assessed as a standardised variance of differences right-minus-left character values (R–L) (3, 4). The distributions of calculated differences were first compared to the normal distribution (Kolmogorov–Smirnoff test, kurtosis, skewness) (5). In order to estimate the association between the FA level of the child's head and selected prenatal factors, multiple regressions were calculated, where y = FA (calculated for each individual and each feature as a standardised absolute difference between measurements on the right and left side of the head) was a dependent variable while independent variables (explanatory) were fourteen stressogenic paragenetic factors (mass increase of the pregnant woman, her past diseases, number of hospital admissions, professional activity, tobacco smoking, alcohol consumption as well as smoking by the mother after birth, smoking by the father during pregnancy, order of birth, kind of delivery, trauma, medicines supporting pregnancy, mother's and father's education). For each of the cephalometric characters, the mean technical error (TEM) and reliability index (R) were estimated and taken into consideration before presenting the study results.

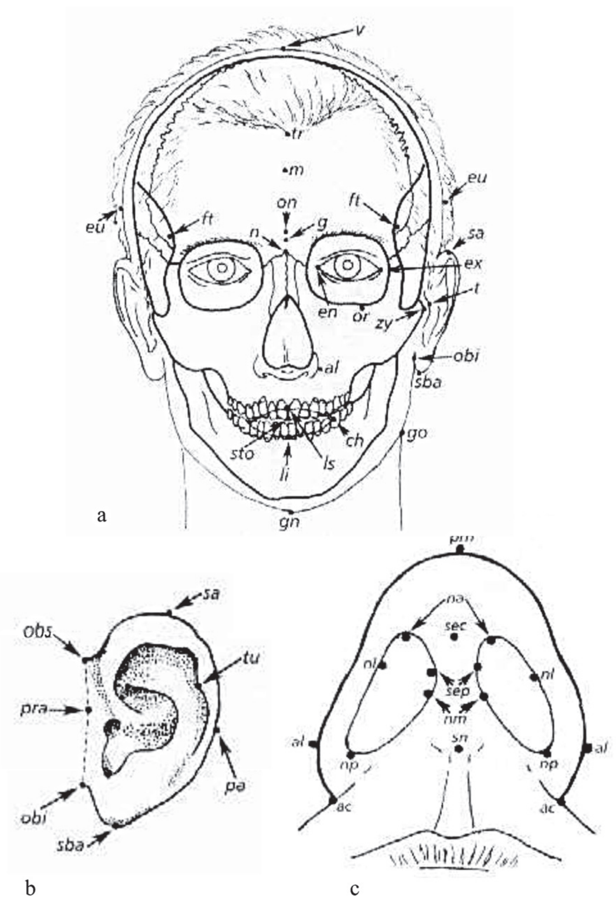

Fig. 1. Anthropometric measurements used in this paper: a – mandible (*go-gn*) and eye (*en-ex*); b – ear (*sa-sba*, *pra-pa*, *obs-obi*); c – nose (*ac-sn*, *al-sn*, *na-np*)

The magnitude of variance due to measurement error in all characters, expressed as a percentage of the variance representing FA, was negligible. Measurement error was assessed using two-way ANOVA in which sides and individuals were entered as factors with a post-hoc Bonfferoni test (6, 7).

RESULTS AND DISCUSSION

For every trait, the distribution of calculated differences between measurements on the right and the left sides of the head was statistically similar to the normal distribution, which means that the observed asymmetry had a fluctuating character (4).

Among girls and boys, the highest level of FA was noted for two measurements of the nose (width of the ala and length of the nostril) and lowest for the length of the auricle and of the mandibular body (Table 1, Fig.1). Differences between the FA level of characters within the same population are often observed (7, 8) and may probably result from the duration of character formation – characters that develop longer are theoretically longer exposed to disturbing factors (9). According to Aparicio & Bonal (10), the characters of a less complex structure seem to be more asymmetric. Various tissues can be variously affected by stressogenic factors. Every structure has its critical period during embryogenesis when the possibility of disturbance and the appearance of pathology of its developmental process considerably increase (4, 11). It is also important whether a given character plays an important role in sexual selection (12, 13). Møller & Pomiankowski (14) have observed a distinct positive correlation between the level of sexual dimorphism of a trait and its level of fluctuating asymmetry. As Farkas (15) reported, in human sexual selection face attractiveness (symmetry in the nose region) plays a very important role.

Table 1. **Fluctuating asymmetry level of head structures with analysis of variance for differences between boys and girls**

Trait	FA	F	p
go-gn			
boys	0.30	3.47	0.06
girls	0.26		
en-ex			
boys	0.49	2.85	0.09
girls	0.44		
sa-sba			
boys	0.20	9.55	0.00
girls	0.39		
pra-pa			
boys	0.61	7.78	0.01
girls	0.68		
obs-obi			
boys	0.63	6.02	0.01
girls	0.55		
ac-sn			
boys	0.54	3.24	0.07
girls	0.51		
al-sn			
boys	0.77	2.02	0.16
girls	0.77		
na-np			
boys	0.68	0.45	0.50
girls	0.62		

Both measurements of the ear (length and width) are statistically more asymmetric in girls. The other traits showed a higher level of FA in boys, although a significant difference was observed only for the height of the ear base (Fig. 2). The direction of sexual dimorphism of FA in vertebrates described in the literature differs. A higher FA level in females was observed among Hadza people in Tanzania (16) and natives of South African Republic (17). An opposite situation was observed by Gray and Marlowe (16) in white Americans. The lack of sexual differences in FA level was also noticed (18–20). However, usually male individuals show a higher level of FA (10), which is often linked to their higher ecosensitivity and less efficient mechanisms of development stabilisation.

All fourteen prenatal factors taken together explain on average about 7% (in case of boys) and below 3% (in case of girls) of FA variability (Table 2, Fig. 3).

The set of explanatory variables (declared alcohol consumption by mother, smoking of tobacco by father and tragic experience during pregnancy), only in case of boys showed a correlation with the FA level of child's head (Tables 3, 4). A declared trauma during pregnancy visibly disturbs stabilisation mechanisms during auricle and nose development in boys. A distressing trauma experience results in an increased cortisole concentration in blood. This hormone is taking part in carbohydrate metabolism, and its high concentration in a pregnant woman's

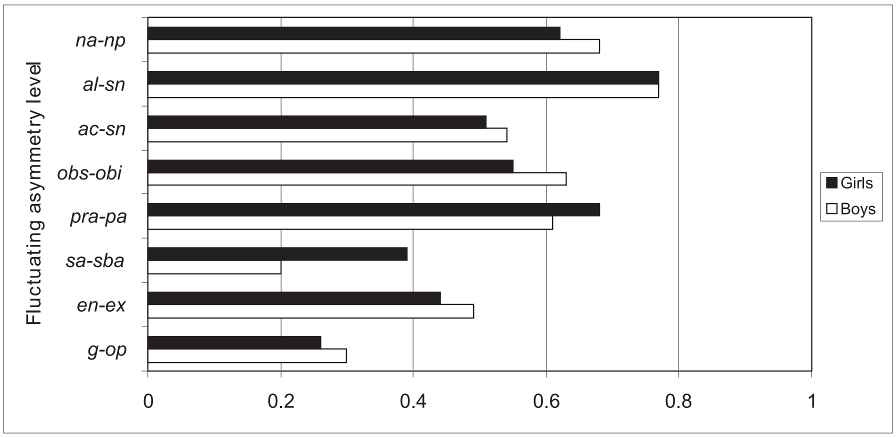

Fig. 2. FA level of analysed cephalometric traits in boys and girls

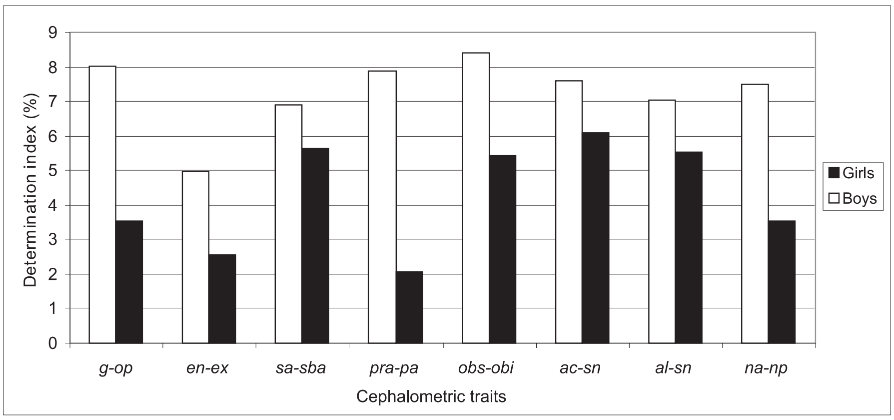

Fig. 3. FA level of head explained by prenatal factors

Table 2. **Regression (R) and determination (R2) indices for the FA level of head explained by the set of prenatal factors under analysis**

Trait	R	R² (%)	p
go-gn			
boys	0.28	8.03	<0.05
girls	1.88	3.52	>0.05
en-ex			
boys	0.22	4.97	<0.05
girls	0.16	2.56	>0.05
sa-sba			
boys	0.26	6.89	<0.05
girls	0.37	5.63	<0.05
pra-pa			
boys	0.28	7.88	<0.05
girls	0.14	2.08	>0.05
obs-obi			
boys	0.29	8.41	<0.05
girls	0.23	5.42	>0.05
ac-sn			
boys	0.28	7.60	<0.05
girls	0.25	6.09	<0.05
al-sn			
boys	0.27	7.04	<0.05
girls	0.24	5.55	<0.05
na-np			
boys	0.27	7.49	<0.05
girls	0.19	3.53	>0.05

Table 3. **Prenatal factors influencing the FA level of boys' head**

Explanatory variables	go-gn	en-ex	sa-sba	pra-pa	obs-obi	ac-sn	al-sn	na-np
Mother's mass increase								
Number of hospital admissions								
Number of diseases								
Tobacco smoking by mother during pregnancy								
Tobacco smoking by mother now								
Tobacco smoking by father	+	+	+					+
Declared alcohol consumption by mother				+	+		+	
Mother's professional activity								
Order of birth								
Trauma			+		+	+		
Kind of delivery								
Medicines supporting pregnancy								
Mother's education								
Father's education								

Only a statistically important correlation (positive + or negative –) was marked.

organism is correlated with the worse oxygen administration to foetal tissues (21, 22).

The boy's face asymmetry depends more visibly on the prenatal environment (the statistically important regression indices were noticed for all the head traits analysed) (Fig. 3). The higher sensitivity of boys to environmental conditions may be

Table 4. **Prenatal factors influencing the FA level of girls' head**

Explanatory variables	go-gn	en-ex	sa-sba	pra-pa	obs-obi	ac-sn	al-sn	na-np
Mother's mass increase								
Number of hospital admissions								
Number of diseases								
Tobacco smoking by mother during pregnancy								
Tobacco smoking by mother now			+					
Tobacco smoking by father						+	+	
Declared alcohol consumption by mother						+		
Mother's professional activity								
Order of birth								
Trauma								
Kind of delivery								
Medicines supporting pregnancy								
Mother's education								
Father's education								

Only a statistically important correlation (positive + or negative –) was marked.

confirmed by the fact that the study set of paragenetic factors showed a more than twice greater percentage of fluctuating asymmetry variability of the head for boys than for girls.

Cieślik & Waszak (23) have noted that prenatal factors have only a limited influence on the morphological development of female foetuses. According to Kaczmarek (24), female organisms have better mechanisms of buffering the results of negative environmental influences.

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