Institute of Experimental Morphology and Anthropology with Museum
Bulgarian Anatomical Society

Acta morphologica et anthropologica, 13
Sofia • 2008

# The Influence of Environmental Factors on Growth and Development in Humans

*E. Godina, I. Khomyakova, L. Zadorozhnaya*

*Institute and Museum of Anthropology, Moscow State University*

2,106 girls and 2,169 boys from 7 to 17 were investigated in 2002-2004 in three urban settlements of the Saratov region: the town of Khvalynsk, and the cities of Saratov and Balakovo. The whole area, particularly the location of Khvalynsk, is characterized by iodine deficiency. The program included about 30 anthropometric measurements, evaluation of developmental stages of secondary sexual characteristics, and information on menarcheal age by the status quo method. For the analysis all data were standardized, and further comparisons were made irrespective of age groups. The significance of differences was assessed by one-way ANOVA. The Khvalynsk children are the smallest in body height and weight with the age of menarche for girls being 13 years 5 months. In Balakovo and Saratov the corresponding figures were identical: 13 years 2 months. Secular changes in Khvalynsk and Saratov children are discussed as compared to the literature.

*Key words*: ecology, growth and development, Russian children, environmental adaptation, secular trend.

## Introduction

The growth process is determined by interactions of endogenous genetical factors (so called "determinants"), endogenous paragenetic factors ("stimulators") and exogenous environmental factors — "modificators" [3]. In this last group the following factors could be named: biogeographical (climate, seasonality, etc) social-economic (parental education and professional qualification, income, socioeconomic family status, living conditions, etc), psychological, anthropogenic and others [7].

One of the powerful natural factors influencing the processes of growth and development is the content of iodine in the environment. It affects growth via thyroid hormones. Approximately 1.5 billion people on our planet are affected by this condition [1]. Iodine deficiency causes the enlargement of the thyroid gland (goiter), the impairment of its functioning, deterioration of physical and mental health and development of serious diseases.

In Russia huge territories are characterized by iodine deficiency. One such territory is the Saratov oblast (region). In the soil of this area, particularly in Khvalynsk rayon, iodine levels are significantly low: 0.78 mkg/kg $\pm$ 0.32 versus normal values of 5-7 mkg/kg [5]. There is a deficit of other trace elements, such as Cu, Co, Zn with additional effects on thyroid deficiency.

## Materials and Methods

The data were collected in 2002-2004. 2,106 girls and 2,169 boys from 7 to 17 were investigated cross-sectionally in three urban settlements of the Saratov region differing in the degree of iodine deficiency and in socio-economic development. The town of Khvalynsk (group 1) has only 15,000 inhabitants, does not have any industries and is very close to rural areas judging by the lifestyle of the population. One of the important characteristics of this area is the high degree of iodine deficiency. The median of ioduria in children of prepubertal age is 24 mkg/l [10].

In the cities of Balakovo (group 2) and Saratov (group 3) the same indicators are correspondingly 42.9 and 32.4 mkg/l, which can be considered a moderate iodine deficiency [10]. At the same time, the three localities differ in their degree of urbanization and industrialization: the city of Balakovo, population 220,000, is highly industrialized and has a nuclear power station; the city of Saratov, population around 1,000,000, is the regional capital and is highly industrialized. About 78 % of all investigated subjects were Russians; 4 % were Ukranians and Byelorussians; 86 % were born in the geographical localities where they were studied.

*Anthropometric program* included a large number of anthropometric measurements taken according to the standard techniques [6,4]. The children were measured during or immediately after school-hours; an age group consisted of children whose age falls within the interval $\pm$ 6 months of the whole year (e.g., 7-year olds: from 6.5 to 7.49, etc.).

The body mass index (BMI) of the studied subjects was calculated as weight (kg) divided by height $(m)^2$.

Besides anthropometric measurements, stages of secondary sexual characteristics were assessed. Breast development, axillary and pubic hair for girls; age at menarche was evaluated by the status quo method. Voice mutation, nipple enlargement, axillary and pubic hair and a number of other indicators were assessed for boys.

The *questionnaire* contained information on parental profession and education, family income, number of children in the family, birth order, birth weight and length of the individual investigated.

To follow *secular changes*, literary data from the 1920s, 1950s and 1960s were used.

*Statistics*: The data obtained were standardized and Z-scores were calculated. The significance of differences was assessed by a Scheffe test (one-way ANOVA). Principal component analysis, canonical analysis was used. Data analysis was conducted with Statistica 6 software. For the secondary sexual characteristics, the median age of their development was calculated from accumulated frequencies graphs.

## Results

Khvalynsk children, both boys and girls, were smaller in stature and weight if compared to their peers from the two bigger cities. However in chest circumference they are either bigger (boys) or equal (girls). In BMI Saratov children are ahead of their counterparts from Khvalynsk and Balakovo in prepubertal age but in later ages have the same or even smaller mean values.

In such measurement as leg length, the children in Khvalynsk are the shortest: e.g., in 17-year-old males of Khvalynsk, Balakovo and Saratov the corresponding mean values are 94.71, 96.05 and 96.61 cm; in females — 85.76, 89.76 and 87.72 cm. During the whole growth period the children of Khvalynsk have smaller values of biacromial and bigger values of biiliac diameter, though the differences are not sta-

tistically significant. Interpopulation comparison of skinfold thickness in boys shows a clear gradient of increasing their values in the order Khvalynsk-Balakovo-Saratov. Among girls, Balakovo females at certain ages and for certain skinfolds (subscapular, triceps) exceed their counterparts from the two other localities.

In skinfold thickness there is a definite decrease of values in the boys and girls of Khvalynsk; the level of significance varies for different skinfolds from $p<0.001$ to $p\leq0.02$. In Balakovo girls the values of biceps and forearm skinfolds are lower than in their counterparts from Saratov ($p\leq0.001$).

Thus, it can be concluded that the degree of differences between the three groups studied varies: the children from Balakovo in some traits are close to their peers from Khvalynsk, and in some other traits to those of Saratov. There are also some gender differences in variations of growth parameters.

Besides morphological parameters, characteristics of sexual maturation were also studied. Khvalynsk children of both sexes are characterized with the highest values of those indices, i.e. with a delayed process of sexual maturation. For Balakovo children there are trends of both later and earlier maturation, depending on the gender of the children. Balakovo boys have an intermediate position in terms of sexual maturation between the other two groups; while girls for some characteristics display even earlier ages than the girls of Saratov. The major marker of sexual maturation — age at menarche — is the same for the girls studied in Balakovo and Saratov (13 years 2 months) and 3 months later in Khvalynsk (13 years 5 months).

## Discussion

The results show that the children of Khvalynsk and Saratov are clearly differentiated from each other. Balakovo children in some way are closer to the Khvalynsk group. This is rather unexpected as both Balakovo and Saratov are big cities and one could expect a similarity in the parameters of children's growth.

In terms of iodine deficiency, Khvalynsk is the town most severely affected by this adverse factor, while both Balakovo and Saratov are characterized with only a moderate degree of iodine deficiency.

Observed variations can also be explained by socio-economic differences in the three populations. Though Khvalynsk is a local district center, in terms of urbanization and economic development it is much less advanced than Balakovo or Saratov. The number of families where parents have a higher education is much lower here, while the number of families with several children is higher. At the same time, in Khvalynsk there is a high level of parental unemployment and mortality.

Balakovo is a relatively young city; its development was closely connected with the construction of a nuclear power station and its functioning. That is why about 40 years ago the city became a center of local migration from adjacent rural areas. We think that this might be one of the reasons why the children of Balakovo are in some ways closer to their peers from Khvalynsk than those from Saratov. It may also explain why we did not find the usual gradient of increase of body parameters parallel to the population increase.

Saratov is a large industrial city with a population almost equal to 1,000,000. It is a city with a long and important history. In the early 20$^{th}$ century, long before the revolution of 1917, it was one of the most developed cities of the Russian Empire, a center of trade and industry, of highly developed agriculture.

According to our results, it is characterized by the largest values of growth parameters in children and adolescents and stability of population structure.

Because the children of Saratov were measured several times during the 20th century we were able to compare our results with historical data [11].

While stature was increasing during those years, such traits as weight, chest circumference and BMI are characterized by negative changes, which are more clearly expressed in girls of older ages. At the same time, girls are also characterized by negative changes in such traits as pelvic breadth.

These results coincide with those obtained early for a young Moscow generation. It was shown that there were important changes towards more leptosomic (from Greek *leptos* — narrow, *soma* — body) morphotypes in young males and females living in Moscow [8, 2].

In sexual maturation there were typical changes towards early ages from 1929 to 2004. Thus, the median menarcheal age has changed from 14 years 5 months in 1929 to 13 years 5 months in 1959, and 13 years 2 months in 2004.

For Khvalynsk children it was possible to follow certain secular changes comparing the results of the present study with the data by Kakorina and Tcheplyagina [9] who examined Khvalynsk children in 1991. For the past decade there were some negative changes in body dimensions both for boys and girls. Even stature decreased significantly for an 11-year period: from 163.7 to 160.85 cm for 15-year-old girls, and from169.4 to 166.28 for 15-year-old boys. The reason for such a decrease may be the negative socio-economic changes in Khvalinsk after "perestroika".

*Acknowledgements.* The work was supported by the Russian Foundation of Basic Research, grants NoNo 05-06-80390-a, 05-06-80907-a; and Russian Foundation of Humanities Research, grant No 04-06-00260-a.

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