Some Trends in the Somatic Development of Children and Adolescents under Iodine-deficiency: Materials from the Saratov Region

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Abstract 2,106 girls and 2,169 boys from 7 to 17 were investigated in 2002–2004 in three urban settlements of the Saratov region (Povolzhe area): the town of Khvalynsk, population 15,000, with a low level of industrialization; the city of Balakovo, population 220,000, highly industrialized and with a nuclear power station; and the city of Saratov, population around 1,000,000 a regional capital, and also highly industrialized. The whole area, particularly the location of Khvalynsk, is also characterized by iodine deficiency (iodine concentration is 0.78 mkg/kg v. normal values of 5–7 mkg/kg).

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. Information on parental occupation and education, as well as number of children per family was collected by questionnaire. For the analysis all the data were standardized, and further comparisons were made irrespective of age groups. The significance of differences was assessed by one-way ANOVA.

For height, weight and chest circumference there are significant differences among the three populations \( p < 0.001 \), with Khvalynsk children being the smallest in body height and weight. However, in chest circumference they are close to or even bigger (girls) than Balakovo children. The children from Khvalynsk are characterized by iodine deficiency (iodine concentration is 0.78 mkg/kg v. normal values of 5–7 mkg/kg). In Balakovo and Saratov, the corresponding figures are identical: 13 years 2 months (13.17).

The purpose of the present study was to compare growth parameters in three populations of the Saratov region living in the areas differing in the degree of iodine deficiency and in socio-economic development.

Introduction

Iodine content in the environment is one of the powerful natural factors influencing the process of growth and development via thyroid hormones. Approximately 1.5 billion people on our planet are affected by this condition (Bogin, 1999). 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.

Numerous investigations have shown the effect of iodine deficiency on growth and development at different stages of ontogenesis: in the intrauterine period, in newborns, and in childhood and adolescence (Binns, 1998; Hetzel et al., 1987; Kavishe, 1999; Kurnacheva, 2003; Scott, Duncan, 2003; Svinarev, 2002; Scheplyagina et al., 1995, 2001, 2003; etc.). The impact of iodine deficiency can be also seen in adults. Green (1973) showed an decrease in stature of 4 cm for females and 5 cm for males in an Ecuador Indian population inhabiting an iodine-deficient area as compared with their peers from more favourable environments.

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 the so-called Khvalynsk rayon, iodine levels are significantly low: 0.78 mkg/kg±0.32 versus normal values of 5–7 mkg/kg (Bolotova, 1995). There is a deficit of other trace elements, such as Cu, Co, Zn with additional effects on thyroid deficiency.

The purpose of the present study was to compare growth parameters in three populations of the Saratov region living in the areas differing in the degree of iodine deficiency and in socio-economic development.

Materials and Methods

For this purpose materials collected by the authors in 2002–2004 are used. 2,106 girls and 2,169 boys from 7 to 17 were investigated in three urban settlements of the Saratov
The town of Khvalynsk, though a rayon (district) center, has only 15,000 inhabitants, does not have any industries and is very close to rural areas judging by the lifestyle of the population. As was already mentioned, 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 (Svinarev, 2002).

In Balakovo and Saratov children the same indicators are correspondingly 42.9 and 32.4 mkg/l, which can be considered a moderate iodine deficiency (Svinarev, 2002). 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.

**Anthropometrical program:** A large number of anthropometric measurements were taken according to standard techniques (Bounak, 1941; Weiner and Lourie, 1981). 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.).

Subjects were measured in their bare feet, wearing only underwear. Weight was taken using a battery-operated digital weighing scale (precision 100 g).

Height and leg length (sum of the heights of iliospinale and symphysis points divided by two) were measured using an anthropometer (1 mm precision). Body diameters (biiliac, bicristal, chest width and chest depth) were measured using a spreading caliper (1 mm precision). Chest, waist, arm, thigh and calf circumferences were measured using a plastic measuring tape (5 mm precision). Chest circumference was measured at the union of the 3rd and 4th sternebrae. Subcutaneous skinfolds (subcapsular, biceps, triceps, abdomen, thigh and calf) were measured using a skinfold caliper, “Best modification” (1 mm precision).

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. Three categories of parental education—separately for fathers and mothers—were chosen: 1 – school education (at least 8 classes); 2 – specialized secondary education (college, technical school, etc.); 3 – higher education (universities). As for ‘number of children per family’ three groups were also formed: 1 – one child, 2 – 2 children, 3 – more than 2 children.

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 Scheffé 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

As can be seen from Figs. 1 and 2, Khvalynsk children, both boys and girls, are 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 biliac diameter, though the differences are not statistically 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.

Because it is difficult, if not completely impossible, to analyze the differences in anthropometrical parameters for different age groups in different localities, an analysis of variance (one-way ANOVA) was used for standardized values (Z-scores) of different traits.

Some of the results are shown in Fig. 3. The boys of Khvalynsk have significantly smaller stature, weight and BMI ($p<0.001$); in chest circumference the differences are not significant. In girls significant differences are revealed only for stature ($p<0.001$) but not for weight, or BMI. In chest circumferences the smallest values are registered for Balakovo girls. The differences between the girls of Khvalynsk and Balakovo are non-significant, but between those girls and girls from Saratov highly significant ($p<0.001$).

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 $p=0.02$. In Balakovo girls the values of biceps and forearm skinfolds are lower than in their counterparts from Saratov ($p=0.001$).

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.

For integral analysis of all investigated traits the technique of multiple discriminant (canonical) analysis was used. In this analysis, new integral characteristics -canonical variables were
Fig. 2  Growth curves of body dimensions in girls of the Saratov region.

Fig. 3  Comparison of morphological parameters in children of the Saratov region: 1 – Khvalynsk; 2 – Balakovo; 3 – Saratov.
calculated. The distribution of the values of those variables for each group in two-axial space gives a possibility for a more advanced interpretation of interpopulation variability.

The results of the canonical analysis are shown in Fig. 4.

Besides morphological parameters, characteristics of sexual maturation were also studied. In Table 1 the median ages of the development of secondary sexual characteristics, irrespective of the stage of their development, are presented for boys and girls of the three groups studied. As can be seen from this Table, 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 (See review: Godina and Miklashevskaia, 1990).

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 20th 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 the historical data. There were three other series of measurements: in 1929 (Pyaternev, 1929), 1959 (Solovyeva, 1962), and 1969 (Solovyeva, unpublished.).

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 (Fig. 5). At the same time, girls are also characterized by negative changes in such traits as pelvic...
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 (Godina et al., 1999; Godina, 2001, 2003; Godina and Yampolskaya, 2004).

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 Scheplyagina (1998), 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 from 169.4 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”.

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References


Bolotova NV (1995) Endemic goiter in children (etiology, epidemiology, prognosis). (Doctor Thesis of Medical Sciences), Saratov, [In Russian]

Bounak VV (1941) Anthropometry. Moscow, 1-367 [In Russian]

Godina EZ (2001) Trends in growth changes in Russia in time and space. (Doctoral Thesis of Biological Sciences), Moscow [In Russian]


Godina EZ, Khomyakova IA, Gilyarova OA, Zadorozhnaya LV, Purundjan AL (1999) Modern trends in secular changes (the study of growth parameters in Moscow schoolchildren). In Materials of the Congress of Russian Pediatricians. Soyuz Pediatrov Rossi, Moscow, 113–114 [In Russian]

Urboecology. Nauka, Moscow, 92–102 [In Russian]
Hetzel BS, Dunn JT, Stanbury JB (eds.) (1987) The Prevention and Control of Iodine Deficiency Disorders. In ICCIDD Monograph. Elsevier Science Publ BV (Biochemical Division), Amsterdam, 345
Kakorina EP, Scheplyagina LA (1998) Physical development of schoolchildren from 6 to 15 in Khvalynsk rayon of Saratov region. In Materials on physical development of children and adolescents in urban and rural areas of Russian Federation 5, Moscow, 100–101 [In Russian]
Kurmacheva NA (2003) Prevention of iodine-deficiency in the first year of life (medico-social aspects). (Doctor Thesis of Medical Sciences), Moscow [In Russian]
Pyaternev VS (1929) Evaluation of sexual maturation in women. Forensic expertise 11: 10–15 [In Russian]
Svinarev MYu (2002) Clinical-epidemiological properties of iodine deficiency in children. (Doctor Thesis of Medical Sciences), Moscow [In Russian]

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