

**FEATURES OF DEVELOPMENT OF CHILDREN LIVING
IN THE NORTHERN RUSSIAN REGIONS WITH VARIOUS
LEVEL OF IODINE DEFICIENCY**

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ABSTRACT

The extreme of the environment in the North is determined not only by the harsh climatic conditions but also by a low diversity of nutrition with deficiency of vitamins and minerals necessary for the organism. A decrease of the bioelements in the body may lead to elementosis of mineral metabolism. One of these main diseases in Russia is endemic goiter typically associated with iodine deficiency. According to research, it is found that the southern areas of the Arkhangelsk region are the most iodine-deficient. A mild case of endemia was detected in the northern areas of the region which are located on the White Sea coast.

The spectrum of disorders in a child's development caused by iodine deficiency is rather wide. The iodine deficiency in children causes a decrease in immune reactivity, chronic diseases, neuropsychiatric and cognitive impairment. Insufficient intake of iodine leads to dysontogenesis of higher mental functions, formation of mental retardation of varying intensity in severe cases and in milder cases – borderline or partial intellectual disabilities. The dependence of the incidence of mental disorders on the factor of iodine deficiency is often explained by that iodine deficiency leads to a weakening of adaptability and stress resistance of the nervous system, reducing sensitive threshold to various psychosocial, genetic and exogenous organic factors.

The study aims to determine the influence of the goitre endemia level on morphofunctional and psychophysiological maturation of first-graders in the Arkhangelsk region.

The research involved first-graders of Arkhangelsk, Mezen, Onega and Pinega schools. The total amount of participants was 467 children, among them 230 girls and 237 boys.

Assessment of morphological maturity was carried out in terms of body length, school maturity, number of erupted permanent teeth and indicator of development options. Functional maturity was assessed using handgrip test and hemodynamics parameters. The "Method of assessing the level of development of visual perception of children 5-7.5 years " was used as the assessment of psychophysiological maturity. Toulouse-Pieron test that involves the assessment of psychophysiological maturity in terms of velocity and accuracy of psychomotor activity was also used.

To estimate the impact of iodine endemia on the biological maturity of children we conducted a correlation and factor analysis. The analysis of the structural correlation model of the system of biological maturity indicators in first-graders living in a mild level of goitre endemia allows to identify 3 system-forming complexes: morphological, dynamometric and hemodynamic. First-graders who live in the severe iodine endemic conditions are characterized by 2 system-forming complexes: morphological and dynamometric. It is not possible to distinguish the system-forming complexes in a group of children living in conditions of moderate iodine endemia.

Factor analysis carried out for indicators of biological maturity in groups of different goitre endemia degrees showed significant differences in the factor model of biological maturity. Indicators of biological maturity of children living in the mild goitre endemic conditions are grouped into 6 factors: the general factor includes indicators of dynamometry, factor 2 describes features of cardiovascular system development, other factors have different structure. Indicators of biological maturity of children living in the average goitre endemic conditions are grouped into 5 factors: general factor consists of indicators of cardiovascular system development, factor 2 illustrates morphological features of development, factors 3, 4, 5 have different structure. Indicators of biological maturity of children living in the severe goitre endemic conditions are grouped into 5 factors: general factor includes indicators of morphological development, factor 2 characterizes dynamometric indicators of development.

It was found that the goitre endemia level in the area of residence affects the rate of biological maturation of first-graders: children living in the area with mild goitre endemia are more mature in terms of most morphological and functional parameters.

Analysis of biological maturity of first-graders living in areas with diverse goitre endemia levels elucidated that the indicators of psychophysiological maturity to be less informative. That indicators do not constitute either a system-forming complex or a common factor in the system of biological maturity.

Comparison results of correlation and factor models of the biological maturity system indicate significant differences in the system of biological maturity of children living in different endemic conditions.

Keywords: iodine-deficient, development, children, North.

INTRODUCTION

Living in the uncomfortable conditions of Far North leads to the development of a complex of metabolic features related to the influence of environmental factors which reveals itself in children's development retardation [1], [2]. Lack of vitamins and microelements necessary for human body can lead to the development of the mineral metabolism elementosis. One of the most widespread elementoses in Russia is goitrous endemia caused mainly by iodine deficiency. The degree of manifestation of goitrous endemia in the northern regions ranges from mild to severe. It is known, that the iodine deficiency leads to a decrease in immune reactivity, chronic diseases, neuropsychiatric and intellectual disorders in children [3]. In iodine-deficient areas mental retardation is 2 times more common, up to 15% of schoolchildren have learning difficulties, and anthropometric measurements

decrease. It has been established that 85, 5% of primary school children in the area of moderate iodine deficiency have deviations in some indicators of the intellectual-mnestic sphere. Even well-performing children have the lag of 56% in the attention sphere, of 30% in perception, of 17% in fine motor skill activity; the rate of mental activity has been reduced by 20%. Numerous studies have shown that inadequate iodine intake leads to the dysontogenesis of higher mental functions, to mental retardation of varying severity and in milder cases – to borderline or partial intellectual disorders [4].

Following the tasks the study was carried out in three stages:

1. Assessment of biological maturity of children according to morphological criteria (body length, school maturity indicator). School maturity indicator or the ratio of the body length to combined height of head and neck has been chosen deliberately. The younger the child is, the larger proportion of his body length includes the head and such a part of the “upper segment” as the face height. Body length and head height were measured with the help of anthropometer. The obtained data were compared with the standard ones for assessing morphofunctional development of children [5].
2. Assessment of biological maturity of children according to functional criteria (dynamometry, hemodynamic criteria: heart rate and arterial tension). Dynamometry or handgrip strength was measured with the help of a handheld dynamometer. Hemodynamic indices were determined by pulse rate, systolic and diastolic blood pressure according to Korotkov’s method.
3. Assessment of psychophysiological maturity (rate of mental work capacity and attention focusing, level of visual perception development). Level of visual perception development was measured according to the “Methodology for assessing the level of visual perception development in 5-7.5 years old children” M. Bezrukikh, L. Morozova [6]. The methodology is a modification of the well-known methodology “Developmental test of visual perception” M. Frostig (1966) [7]. Characteristics of child’s attention and mental work capacity were determined using the Toulouse-Pieron test (psychomotor velocity and accuracy).

The children were divided into three groups: those living in the area with a mild degree of goitrous endemia (349 people), with a moderate degree of goitrous endemia (25 people) and with a severe degree of goitrous endemia (93 people). At the time of the survey all the children were healthy or in remission. The survey was conducted in the morning with the written consent of the parents, teachers and the oral consent of the children themselves. The experiment was conducted in accordance with the ethical standards, represented in Declaration of Helsinki and European Community directives (8/609 EC).

Mathematical and statistical analysis of the survey results was carried out using the application package Microsoft Excel, SPSS 15.0. The statistical processing of the results included an analysis of the distribution of traits (mean values M) and

variability relative to the mean (standard deviation δ). In connection with the different number of people in each group, we used the non-parametric method of comparison with the help of the Wilcoxon signed-rank test. To analyze the structure of correlations of the studied variables, correlation and factor analysis was used. Correlation analysis was performed with the calculation of the Kendall rank correlation. The obtained average values of criteria for biological maturity were subjected to factor analysis (principal component analysis). The initial factorial pattern was rotated by the varimax method, and variables with factor loading of more than 0.50 were further analyzed. According to the results of all statistical methods, the differences were considered reliable when the significance level was $p < 0.05$.

The analysis of variance didn't reveal a significant effect ($p > 0.05$) of gender on any indicator of first-graders' biological maturity. This made it possible in the present study, when conducting statistical procedures, not to take into account the influence of gender.

As a result of the study we found that the indicators of the average body length in children living in areas with varying degrees of goitrous endemia do not have significant differences. In most children, the average values of body length correspond to or exceed the age standards (see table). Low values of body length are more common in the area with severe goitrous endemia ($24.73 \pm 4.47\%$). School maturity is significantly lower in the group of children from the region with severe goitrous endemia. According to a number of researchers, acceleration in the North doesn't contribute to the adaptation of children, since in most cases it leads to asthenization [8].

The results of the study of biological maturity in children according to functional criteria revealed that the values of dynamometry in most children are below the age standards. Significant differences were found in the rates of morphological maturation in terms of hand strength in children living in areas with varying degrees of goitrous endemia (see table). For example, in children living in the area with a severe degree of goitrous endemia, the average right hand strength is 8.22 ± 2.31 kg which is lower than that one in areas with a mild and moderate degree. Among children living in the area with severe goitrous endemia, $55.91 \pm 5.15\%$ make up the group with reduced right hand strength (see Table 1).

Section ECOLOGY AND ENVIRONMENTAL STUDIES

Table 1. Number of children (%) with different indicators of biological maturity living in areas with various goitrous endemia

Biological age indicators	Degree of goitrous endemia								
	Mild (n=309)			Moderate (n=65)			Severe (n=93)		
	Below the average	Average	Above the average	Below the average	Average	Above the average	Below the average	Average	Above the average
Body length	10,63± 1,7	44,25± 2,7	45,12± 2,7	7,69± 5,3	19,23± 7,7	73,08± 8,7	24,73± 4,5	38,71± 5,1	36,56± 4,9
School maturity indicator	9,77± 1,6	37,35± 2,6	52,87± 2,7	3,85± 3,8	50,00± 9,8	41,15± 9,8	2,15± 1,5	23,66± 4,4	74,19± 4,5
Right hand strength	37,93± 2,6	60,06± 2,6	2,01± 0,8	42,31± 9,7	57,69± 9,7	0	55,91± 5,2	44,09± 5,2	0
Heart rate	23,27± 4,6	63,51± 2,9	13,22± 3,3	7,69± 5,2	73,08± 8,7	19,23± 7,7	1,07± 1,1	40,86± 5,1	59,14± 5,1
Systolic blood pressure	29,02± 3,6	60,06± 3,0	10,92± 4,4	34,62± 9,3	34,62± 9,3	30,77± 9,1	53,76± 5,2	37,63± 5,0	8,60± 2,9
Diastolic blood pressure	16,09± 4,3	62,36± 2,8	21,55± 4,2	23,08± 8,3	61,54± 9,5	15,38± 7,1	12,90± 3,5	66,67± 4,9	20,43± 4,2
Level of visual perception development	54,60± 3,9	45,40± 3,8	-	73,08±9 ,8	26,92±8 ,7	-	95,7±5, 2	4,30± 2,1	-
Psychomotor velocity	50,86± 3,7	49,14± 7,1	-	38,40± 9,5	61,54± 9,5	-	36,05± 0,5	63,95± 3,5	-
Psychomotor accuracy	38,51± 4,1	61,49± 3,2	-	23,08± 8,3	76,92± 8,3	-	31,11± 0,4	68,89± 2,9	-

The average values of heart rate in children living in areas with varying degrees of goitrous endemia have significant differences and tend to increase with increasing degree of endemia. The data obtained showed that in the area with a severe degree of goitrous endemia in a significant number of children, an increase in the heart rate is noted, which indicates a lag in functional development in this indicator. Average values of systolic and diastolic blood pressure in children correspond to their age. The distribution of the children in groups with different values of blood pressure (see table) showed that among children living in the area with a moderate degree of goitrous endemia, increased systolic blood pressure is

observed more often ($30.77 \pm 7.02\%$). Increased diastolic pressure is observed more often in children living in the areas with mild and severe goitrous endemia ($21.55 \pm 4.15\%$ and $20.43 \pm 4.18\%$, respectively).

In assessing the psychophysiological indicators of biological maturity, it was found that most children have a decrease in psychophysiological development. The results of the study showed that as the degree of goitrous endemia increases, the values of level of visual perception development reliably decrease and the number of children with the lag in the rate of formation of the visual perception system increases (see table). We have not revealed significant differences in the speed of performance of the Toulouse-Pieron test, which indicates a less pronounced effect of iodine deficiency on the values of psychophysiological activity development. The qualitative performance characteristics, assessed by the accuracy of the Toulouse-Pieron test are reliably different in children living in areas with varying degrees of goitrous endemia. Thus, the accuracy of the test significantly worsens with increasing degree of goitrous endemia in the area of residence.

The final stage of our research was to study the correlation of the parameters of morphofunctional and psychophysiological maturity and construct their hierarchy in the structure of the biological maturity of children. A significant number of studies [9], [10], [11] showed that there is a specific development of children in areas with varying degree of iodine maintenance. To assess the impact of the degree of iodine endemia on the indicators of children's biological maturity, we carried out a correlation and factor analysis. The results of the correlation analysis indicate that the number of reliable bilateral correlations ($p < 0.05$) between the indicators of biological maturity in children living in areas with varying degrees of iodine endemia is significantly different. Indicators with the maximum number of correlations: in children living in the areas with severe goitrous endemia – indicators of body length (7) and indicator of development options (8). When analyzing the structural correlation model of the system of biological maturity indicators in first-graders living in the areas with a mild degree of goitrous endemia, it is possible to distinguish 3 system-forming complexes: morphological, dynamometric and hemodynamic. First-graders who live in the severe iodine endemic conditions are characterized by 2 system-forming complexes: morphological and dynamometric.

CONCLUSION

The influence of the level of goitrous endemia in the area of residence on the rates of biological maturation of first-graders is revealed: children living in the area with a mild degree of goitrous endemia are more mature according to the majority of morphofunctional parameters studied.

When analyzing the biological maturity of first-graders living in areas with varying degrees of goitrous endemia, the indicators of psychophysiological maturity turned out to be uninformative, they do not constitute either a system-forming complex or a common factor in the system for ensuring biological maturity.

The results of the comparison of correlation and factor models of the system for ensuring biological maturity indicate significant differences in the system for

ensuring the biological maturity of children living in conditions of various goitrous endemia.

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REFERENCES

- [1] Dobrodeeva L.K. Ecologo-physiological approaches in solution of problems of northern territories division into districts, *Human Ecology, Russia*, vol. 10, pp 3-11, 2010.
- [2] Lukina S.F., Chub I.S., Repina A.P. The anthropometric features of morphophysical development in the 8-10 year-old children with different somatotypes, *Journal of New Medical Technologies, Russia*, vol. 19(4), pp 195-199, 2012.
- [3] Zimmermann M. B., Molinari L., Spehl M., et al. Toward a consensus on reference values for thyroid volume in iodine-replete schoolchildren: results of a workshop on interobserver and inter-equipment variation in sonographic measurement of thyroid volume, *European Journal of Endocrinology*, vol. 144(3), pp 213–220, 2001.
- [4] Baranov A.A., Dedov I.I. Iodine deficiency diseases in children and adolescents: diagnosis, treatment, prevention, *Scientific and practical program of the Union of Pediatricians of Russia and the International Fund for Mother and Child Health, Russia*, 2005, pp 48-48.
- [5] Gurbo T.L. Anthropometric characteristics of constitutional types of children 4-7 years old, *Physical education of children of preschool age: theory and practice, Russia*, 2002, pp 27-33.
- [6] Bezrukikh M.M. Methods of assessing the level of development of visual perception of children 5.0-7.5 years. *Test Guidelines and Results Processing, Russia*, 1996, pp 1-48.
- [7] Frostig M. *Developmental test of visual perception, Revised*, 1966, pp 1-40.
- [8] Gubkina ZD, Tkachev A.V. Features of the hormonal regulation of the reproductive system in women in the North, *Endocrine system and metabolism in humans in the North, Russia*, 1992, pp 45-71.
- [9] Gerasimov G.A., Sviridenko N.Yu. Iodine deficiency disorders. *Diseases of the endocrine system, Russia*, 2000, pp 311-327.
- [10] Sibileva E.N. Transient hyperthyrotropinemia in newborns in iodine-safe area, *Human Ecology, Russia*, vol. 3, pp 21-23, 2004.



[11] Tedder Yu.R., Gordienko P.P. The current state of the problem of iodine deficiency in the Arkhangelsk region, Human Ecology, Russia, vol. 2, pp 6-8, 2002.