

# The Influence of Adequate Iodine Intake on the Level of Stress Resistance and the Capacity of Short-Term Memory in Schoolchildren

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## Abstract

The medical and social significance of adequate iodine intake is due to the fact that even a moderate iodine deficiency reduces the mental potential of the population by an average of 10-15%. The reduction in the level of intelligence in the upper secondary school and in adolescence leads to the accumulation of a stressful factor and problems in the social realization of an individual in the future. This article is aimed at the evaluation of the effect of the adequate iodine administration on the capacity of short-term memory and the level of stress resistance in schoolchildren. The cross-sectional observational study among pupils of the 9th and 11th grades of the upper secondary schools of the Republic of Dagestan with a total of 4858 people, and the average age of 15.11 years was conducted by the authors. As a result of the study, some statistically significant post-test differences between the main and reference groups were found: the number of people with high capacity of short-term memory among the young males and females of the main group was significantly higher than the number of people in the reference group ( $\chi^2 = 271.934$ ; D.f. = 3;  $p < 0.001$ ); the students of the 9th grades in the main group qualitatively improved the memory parameters in comparison with the reference group ( $\chi^2 = 50.772$ ; D.f. = 2;  $p < 0.001$ ); the number of people with a high level of situational and trait anxiety among 9th and 11th grade students of both sexes in the main group was significantly less than in the reference group ( $\chi^2 = 182.135$ ; D.f. = 3;  $p < 0.001$ ;  $\chi^2 = 439.855$ ; D.f. = 3;  $p < 0.001$ ;  $\chi^2 = 210.778$ ; D.f. = 3;  $p < 0.001$ ;  $\chi^2 = 362.172$ ; D.f. = 3;  $p < 0.001$ ). According to the results of the study, the authors came to the conclusion that the preventive administration of potassium iodide preparations at a dose of 150 mcg per day significantly improved the memory capacity, and also reduced the level of anxiety in schoolchildren in regions with mild and moderate iodine deficiency. The optimization of protocols of measures for prevention of iodine deficiency should become a priority task for the healthcare officials.

**Keywords:** iodine deficiency; schoolchildren; short-term memory; stress; anxiety; intelligence.

## INTRODUCTION

The social importance of maintenance of the health of young people is due to the fact that they represent the future reproductive, intellectual, economic, social, political and cultural potential of society [4].

According to the World Health Organization (WHO), the term "Young people" describes the age category in the range of 10 to 24 years, including adolescents (10-19 years) and youth (15-24 years) [3].

Iodine deficiency regions are 2 times more likely to experience mental retardation; up to 15% of schoolchildren experience difficulties in studying [16]. These problems are exacerbated in the upper secondary school, where along with the increase in the level of intellectual load, the level of stress increases in entrants from expecting future examinations, taking place against the background of the process of the completion of puberty and social self-identification.

About two million young people in the WHO European Region suffer from psycho-emotional disorders such as depression, behavioral disorders, anxiety disorders and anorexia nervosa. Twenty percent of teens suffer from the development of the psycho-emotional and behavioral problems [9]. The normal psycho-emotional state of pupils is one of the important factors of training, the basis of

personality formation and high professional suitability in the future [17].

The Republic of Dagestan is one of iodine deficient territories with a high incidence of endemic goiter and other iodine deficiency diseases. The results of recent studies have shown that preventive measures to combat iodine deficiency in Dagestan, especially in rural areas and in the mountainous areas, are still insufficient [14; 15; 6].

In the regions with severe iodine deficiency, the incidence of neuropsychic diseases, including both syndromically defined disorders and their prenosological forms, is higher among children suffering from euthyroid goiter, while the differences in the morbidity are observed in the frequency of cognitive and asthenic disorders due to brain dysfunction and neurotic disorders [18]. However, there remains the question of cases with latent forms of euthyroid goiter, which may already require the preventive administration of iodides, rather than waiting for a clinical manifestation of the disease.

A number of studies show the continuing problem of iodine deficiency in the coastal and non-marine regions of Dagestan with variability from mild to moderate, according to the data of works based on the application of the recommendations of the WHO, the United Nations International Children's Emergency Fund (UNICEF) and

the International Council for Control of Iodine Deficiency Disorders [7; 13; 19; 23].

Given that even a moderate iodine deficiency reduces the mental potential of the population by an average of 10-15% [20; 22; 23], the existing prevention programs show moderate efficiency, and a decrease in the quality of intelligence in the upper secondary school and in the adolescence leads to the accumulation of a stress factor, the search for effective methods of the iodine deficiency prevention among the youth becomes a promising task of the modern public healthcare.

### The purpose of the study

The purpose of the study is to assess the effect of the adequate iodine administration on the capacity of short-term memory and the level of stress resistance in schoolchildren.

### MATERIALS AND METHODS

A cross-sectional observational study was carried out among the schoolchildren of the 9th and 11th grades of the upper secondary schools of the Republic of Dagestan located in the urban and rural regions, including the maritime regions (Makhachkala, Kaspiisk, Dagestanskie Ogni, Izberbash, Derbent) and non-maritime cities (Buinaksk, Kizilyurt, Kizlyar, Khasavyurt, South Sukhokumsk).

#### Composition of the study groups and calculation of the sample

The calculation of the sample size is performed on the basis of data on the prevalence of iodine deficiency disorders in the Republic of Dagestan (16.58% on average in the republic) [13].

The following formula is used for calculation of the sample, taking into account the fact that the attribute on which the calculation is carried out is expressed by the relative value [21]:

$$n = t^2 \times p \times q \div \Delta^2$$

where:

n is the planned sample size;

t is the confidence coefficient, with  $p = 99\% = 3$ ;

p is the prevalence rate (prevalence of the disease) in percent, which is taken from the previous studies; herein, the population prevalence of iodine deficiency diseases is equal to 16.58%;

q is the indicator, equal to the difference of 100% – p% (100% – 16.58% = 83.42%)

$\Delta$  is the maximum permissible error, which is set by the researcher (in our study it is equal to 5%).

Thus, the required sample size is:

$$n = 2^2 \times 16,58 \times 83,42 \div 5^2 = 221,3$$

However, given the expected latent prevalence of iodine deficiency, the planned sample size is multiplied by 10% and amounts to at least 2213 schoolchildren for each of the study groups.

After the calculation of the sample, a target composition of the set sample was conducted taking into account the specified criteria for including and pairing the cases of observation by sex and age. The criterion for the division into the study groups (main and reference) was the information whether the child took iodine-containing preparations at the recommended age-specific dosage (150  $\mu$ g of potassium iodide daily for children over 12) to prevent iodine deficiency by prescription of the doctor or on the initiative of the parents [23]. Thus, the children from the main group received 150  $\mu$ g of potassium iodide daily for the last 6 months to prevent iodine deficiency, and the children from the reference group took no potassium iodide.

The enrollment into the study was preceded by the taking of the informed consent from the parents or the official guardians of the schoolchild.

The average age of the studied schoolchildren was 15.11 years. In order to comply with the principle of ensuring the qualitative representativeness of the sample, this study included the schoolchildren studying in both urban and rural regions of the country.

The general demographic characteristics of the participants in the study are presented in Table 1. Both groups of the study included the reference cases, chosen by the identical characteristics. Thus, the initial characteristics were equivalent ( $p > 0.05$ ).

**Table 1 – General demographic characteristics of the participants in the study**

Characteristics	Main group (n = 2427)		Reference group (n = 2431)		$\chi^2$	D.f.	p-assessment
	abs.	%	abs.	%			
Sex							
Young males	1350	55.62	1341	55.16	0.105	1	0.746
Young females	1077	44.38	1090	44.84			
Grade							
9th grade	1250	51.50	1246	51.25	0.03	1	0.863
11th grade	1177	48.50	1185	48.75			
Place of residence							
City	1476	60.82	1499	61.66	0.366	1	0.546
The region without a status of a city (country/rural settlement/ village)	951	39.18	932	38.34			
Average age, in years (mean $\pm$ SD)	14.68 $\pm$ 1.33		14.54 $\pm$ 1.28		t-test 0.208	D.f.	p-assessment 0.427

The study groups and the data were collected in two stages:

1. The initial data according to the characteristics of the capacity of short-term memory and the state of anxiety were collected one year before the main study (during 2015).
2. The collection and analysis of the observation data in dynamics, against the background of preventive administration of potassium iodide preparations at a dose of 150 mcg per day (psychoemotional sphere and the volume of memory) was conducted during 6 months (from September to December 2016).

*Assessment of the capacity of short-term memory and the level of stress resistance*

To assess the psychoemotional features of the schoolchildren and subsequent dynamic observation, a screening method was used to determine the anxiety using the Spielberger reactive and trait anxiety scale in the modification of Yu.L. Khanin (State-Trait Anxiety Inventory – STAI) [10; 12].

The content of the method is a psychological test, which includes two scales of self-assessment – trait and situational anxiety. Each scale includes 20 questions-statements. For each question, there are 4 possible answers in terms of intensity. The final score can be in the range of 20 to 80 points. When interpreting the indicators, they are guided by the following assessments of anxiety: up to 30 points – low; 31-44 points – moderate; 45 and more – high.

The capacity of short-term memory was estimated using the N-back program. This program is free for online access at <http://brainscale.ru/n-back/training>. The experience of using this program to measure the capacity of short-term memory was demonstrated in a number of studies [1; 2].

The parameters for analysis and the type of variable were:

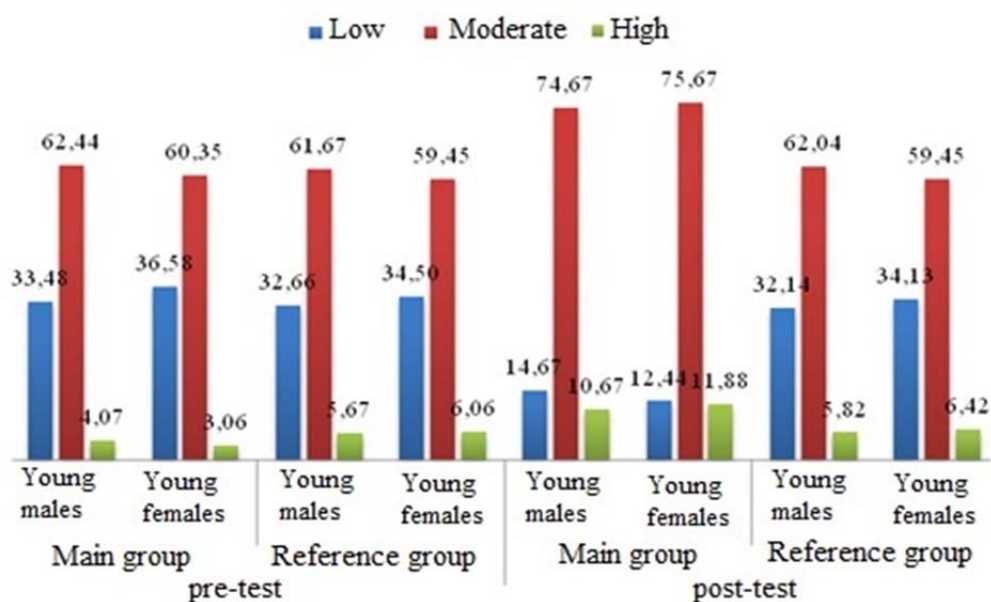
- 1) Quality variable – pre-test (initial short-term memory: low – from 0 to 30%, medium – from 31 to 60%, high – from 61% to 100% of the correct answers from the total number of tasks).
- 2) Quantitative variable – post-test (the volume of memory after 6 months of observation: low – from 0 to 30%, average – from 31 to 60%, high – from 61% to 100% of the correct answers from the total number of tasks).

#### *Statistical analysis*

The results were analyzed using the descriptive statistics methods. For categorical variables, the data were presented in the form of absolute and relative numbers. For quantitative data, the central trends had been measured, and the result was expressed as the mean  $\pm$  standard deviation. For qualitative data, the statistical significance of differences in groups was determined by calculating the chi-square criterion ( $\chi^2$ ), for quantitative data it was determined by using Student's t-test. The critical level of significance of differences in the groups was  $p < 0.05$ . The statistical analysis procedure was performed using SPSS 20 software.

#### **RESULTS OF THE STUDY**

In the course of the study, it was found that, against the background of adequate administration of iodine (the main group) among young males and females, the increase in the level of short-term memory was observed in 6 months. The number of young males and females with a high level of short-term memory in the reference group increased from 4.07% to 10.67% and from 3.06% to 11.88%, respectively, which was significantly different from the post-test values of the reference group ( $\chi^2 = 271.934$ ; D.f. = 3;  $p < 0.001$ ) (Figure 1).



**Figure 1. Dynamics of the memory capacity of schoolchildren during 6 months against the background of adequate iodine administration among the persons of both sexes, %**

Also, it was determined that, against the background of adequate administration of iodine by the upper secondary school students, the increase in the level of short-term memory was observed in 6 months. The number of 9th grade students with a high level of short-term memory in the reference group increased from 4.88% to 7.92%, which was significantly different from the post-test values of the reference group ( $\chi^2 = 50.772$ , D.f. = 2,  $p < 0.001$ ). However, this trend was not observed in the students of the 11th grade. In contrast, the reference group showed the increase in the number of people with a high level of short-term memory – from 3.04% to 5.57%, while this level remained stable and amounted to 2.29-2.21% in the main group (Figure 2).

The results of assessment of the level of situational anxiety in schoolchildren during 6 months against the background of adequate iodine administration among the persons of both sexes showed that the proportion of persons with a high level of situational anxiety was statistically

significantly different in the main group in 6 months of observation and comprised 1.26% among young males versus the initial 6.0%, and among girls it was equal to 2.04% against the initial 10.21% ( $\chi^2 = 182.135$ , D.f. = 3,  $p < 0.001$ ). In the reference group, the pre-test and post-test indices did not differ statistically (Table 2).

The assessment of the dynamics of the level of situational anxiety in schoolchildren during 6 months against the background of adequate iodine administration among students of the 9th and 11th grades also showed a significant reduction in the number of schoolchildren with a high level of anxiety in the main group: from 9.12% to 2.48% in the 9th grades and from 6.54% to 2.72% in the 11th grades. In the reference group, the pre-test and post-test indicators did not differ statistically significantly. Differences in the main and control groups were statistically significant ( $\chi^2 = 439.855$ , D.f. = 3,  $p < 0.001$ ) (Table 3) based on post-test observation data.

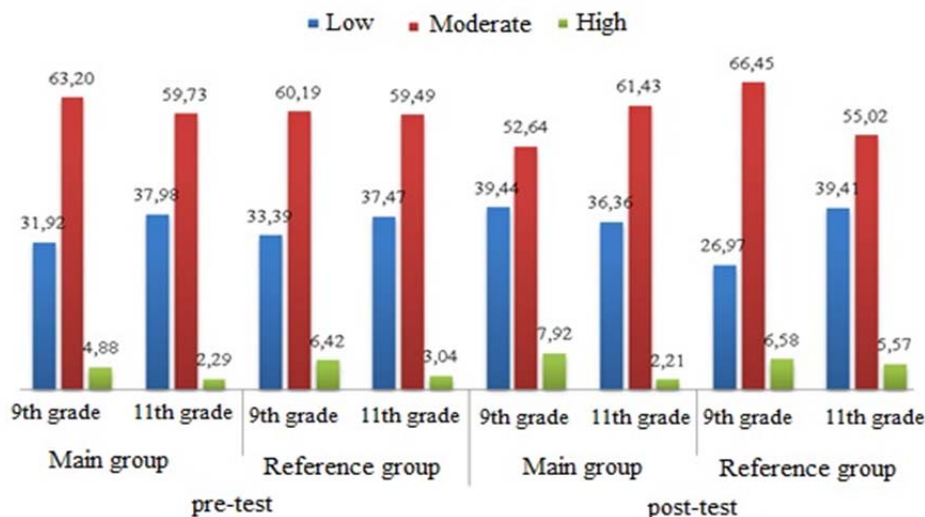


Figure 2. Dynamics of the capacity of short-term memory of the schoolchildren during 6 months against the background of adequate iodine administration among the students of grades 9 and 11, %

Table 2. Dynamics of the level of situational anxiety in schoolchildren during 6 months against the background of adequate iodine administration among the students of both sexes, %

Situational anxiety	pre-test				post-test*			
	Main group		Reference group		Main group		Reference group	
	Young males	Young females	Young males	Young females	Young males	Young females	Young males	Young females
Low	53.41	39.83	52.27	40.18	55.70	46.24	52.13	40.37
Moderate	40.59	49.95	40.19	49.54	43.04	51.72	39.37	50.55
High	6.00	10.21	7.53	10.28	1.26	2.04	8.50	9.08

Note: \* – the differences in the main and reference groups:  $\chi^2 = 182.135$ ; D.f. = 3;  $p < 0.001$

Table 3. Dynamics of the level of situational anxiety in schoolchildren during 6 months against the background of adequate iodine administration among the students of the 9th and 11th grades, %

Situational anxiety	pre-test				post-test*			
	Main group		Reference group		Main group		Reference group	
	9th grade	11th grade	9th grade	11th grade	9th grade	11th grade	9th grade	11th grade
Low	58.48	35.60	58.43	34.68	67.92	41.72	58.03	34.43
Moderate	32.40	57.86	32.02	57.38	29.60	55.56	32.18	57.22
High	9.12	6.54	9.55	7.93	2.48	2.72	9.79	8.35

Note: \* – the differences in the main and reference groups:  $\chi^2 = 439.855$ ; D.f. = 3;  $p < 0.001$

**Table 4. Dynamics of the level of trait anxiety in schoolchildren during 6 months against the background of adequate iodine administration among both sexes, %**

Trait anxiety	pre-test				post-test*			
	Main group		Reference group		Main group		Reference group	
	Young males	Young females	Young males	Young females	Young males	Young females	Young males	Young females
Low	52.67	39.00	52.05	39.45	59.19	46.43	52.05	39.45
Moderate	41.26	50.88	39.45	50.64	38.96	51.72	39.37	50.55
High	6.07	10.12	8.50	9.91	1.85	1.86	8.58	10.00

Note: \* – the differences in the main and reference groups:  $\chi^2 = 210.778$ ; D.f. = 3;  $p < 0.001$

**Table 5. Dynamics of the level of trait anxiety in schoolchildren during 6 months against the background of adequate administration of iodine among the students of the 9th and 11th grades, %**

Trait anxiety	pre-test				post-test			
	Main group		Reference group		Main group		Reference group	
	9th grade	11th grade	9th grade	11th grade	9th grade	11th grade	9th grade	11th grade
Low	57.68	34.58	57.70	34.43	68.24	47.58	57.87	34.26
Moderate	33.68	58.79	32.34	56.71	29.92	47.07	32.50	56.54
High	8.64	6.63	9.95	8.86	1.84	5.35	9.63	9.20

Note: \* – the differences in the main and reference groups:  $\chi^2 = 362.172$ ; D.f. = 3;  $p < 0.001$

The results of the assessment of the index of trait anxiety in schoolchildren during 6 months against the background of adequate iodine administration among both sexes revealed a significant reduction in the percentage of schoolchildren of both sexes in the main group with a high level of trait anxiety: from 6.07% to 1.85% among young males and from 10.12% to 1.86% among young males. In the reference group, the indicators were stable during the observation period (Table 4).

The indicators of trait anxiety in schoolchildren during 6 months of observation against the background of adequate iodine administration among the students of the 9th and 11th grades showed a statistically significant reduction in the proportion of people with a high level of trait anxiety in the main group: from 8.64% to 1.84% in the 9th grades and from 6.63% to 5.35% in the 11th grades. The reference group showed a slight increase in the number of persons with a high level of trait anxiety, both among the 9th and among the 11th grades (Table 5).

#### DISCUSSION

The influence of the adequate iodine administration on the condition of the intellectual and psychoemotional sphere has been studied in a number of population studies [5; 8]. Herein, the authors studied the indicators of the capacity of short-term memory, as well as the level of situational and trait anxiety in the schoolchildren of both sexes, in view of the possibility of gender influence on these spheres, and among the students of the 9th and 11th grades, taking into account the age characteristics of this contingent and the increased emotional load during passage of the examination periods.

The system of modern education implies a special complexity for students. Studying in upper secondary school is associated with greater responsibility for the schoolchildren, and also requires considerable memory reserves, since the amount of information received daily requires its preservation and active application [24].

The schoolchildren with high anxiety level may regard any external incentives as dangerous and connect them with specific situations of threat to their status, self-esteem and self-assessment. The situational anxiety characterizes the level of stress at the moment, and the trait anxiety is a vulnerability to the impact of various stressors in general. The higher the level of trait anxiety, the higher the likelihood that the student will feel anxious in a threatening (or seemingly threatening) situation, and this anxiety will be relatively stronger. In this case, the emotional sphere "overlaps" the cognitive one and reduces the effectiveness of learning activities. Prognostically very high trait anxiety level can indicate the presence of a neurotic conflict and cause the psychosomatic illnesses, as well as propensity for suicidal behavior [11].

According to the results of this study, both the young males and the young females qualitatively changed the amount of short-term memory and the level of situational and trait anxiety against the background of adequate iodine administration, by taking 150 mg of potassium iodide per day to prevent the iodine deficiency. However, in the 11th grades, even against the background of adequate iodine administration, the authors registered a stably high number of people with a high capacity of short-term memory, which may be due to the influence of the intervening factors (confounding factors), such as the increase in the intensity of the educational process for preparing for the final exams and the psycho-emotional stabilization due to the completion of the process of puberty.

Certainly, the observational nature of this study limits it significantly. The data obtained during an interventional study corresponding to the design of a randomized controlled study could be of greater reliability. However, taking into account the goal, the authors were interested in passive observation, and the interventions in obviously known regions with iodine deficiency would not

look ethical in relation to the children of the reference group, as the effect of adequate daily administration of iodine has been proved earlier in a variety of studies. Also, the current design of the study limited the ability to verify the compliance of iodine medications, taking into account the characteristics of their prescription by the physicians who were not the providers of this research. In view of this, the authors could not reliably track the regularity or duration of the course of administration of iodine preparations, and the application of the questionnaire method was influenced by a number of systematic errors, such as memory errors and deliberate distortion of answers to questions of the questionnaire.

### CONCLUSION

A preventive administration of potassium iodide preparations at a dose of 150 mcg per day significantly increases the capacity of short-term memory, and also reduces the level of reactive and trait anxiety in schoolchildren of both sexes, pupils of the 9th and 11th grades of the upper secondary schools in regions with weak and moderate iodine deficiency. The optimization of the protocols of preventive measures to combat the iodine deficiency should become the primary task for the public healthcare officials.

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