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Changes in Cognitive Functions of Pupils under Conditions of Iodine Deficiency

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Keywords: iodine deficiency; thyroid homeostasis; cognitive functions

Abstract.

Clinical and physiological examination of 38 children which latent hypothyroidism (the main group) and 176 apparently healthy persons of intact region (the control group) at the age from 8 to 17 years living in endemic region was carried out. To determine the functional state of the thyroid gland in blood serum the content of total triiodothyronine (T3), total and free thyroxin (T4, fT4), thyroid-stimulating hormone (TSH) of adenohypophysis were determined as well as urinary iodine level was examined. The cognitive functions were characterized by the indices of attention as the result of correction test and rate of sensomotor reactions which were evaluated using modified Schulte tables. It was detected that in all children with latent hypothyroidism regardless of age work accuracy rate decreased, attention span increased slowly, fatigue developed early and rate of information analysis significantly reduced already within the first 5 minutes in comparison with analogical data in healthy children. When being tested children of the control group made fewer mistakes, the tempo of doing tasks remained higher for 5 minutes. There was a correlation between the indices of correction test, sensomotor reactions and data of thyroid status of pupils.

Problem statement and analysis of the recent research

Iodine deficiency overcome is an important medical and social problem in Ukraine. However, environmental problems and insufficient level of preventive measures to eliminate iodine deficiency are accompanied by increase in thyroid pathology including ecdemic regions. In particular, iodine deficiency condition may occur in case of this trace element assimilation disorder (on the background of competitive capture of other halogens by thyroid gland) under the conditions of essential trace elements (selenium, iron, zinc) deficiency or influence of toxic trace elements (lead, cadmium) [1, 2, 5]. Iodine deficiency in children is especially dangerous because the functional ability of the thyroid gland is essential to ensure the necessary level of metabolic processes of the developing body, determines the child's possibility to implement the genetic program of mental and intellectual development [6, 8].

The objective of the research was to study the ratio of thyroid status and physiological development of children with latent hypothyroidism living in endemic regions.

Materials and methods of the research

Examination of 38 children which latent hypothyroidism (the main group) at the age from 8 to 17 years living in endemic region and 176 apparently healthy persons of intact region (the control group) was carried out. All examined children were divided into 3 groups by age: Group I consisted of children at the age of 8 to 10; Group II included children at the age of 11 to 14; Group III consisted of children at the age of 15 to 17. Literature data about the peculiarities of physical development and endocrinologic status of children laid the basis for such division. The clinical data were obtained by determining the complaints, past medical history and performing physical examination.

In order to determine the functional state of the thyroid gland in blood serum the content of such thyroid hormones as total triiodothyronine (T3), total and free thyroxin (T4, fT4), thyrotropin of adenohypophysis were determined using immunoenzyme method [3]. The level of iodine excretion in spot urine was investigated according to Sandell-Kolthoff reaction using Dunn's test to clarify iodine supply in children [8].

Cognitive functions were characterized by the indices of attention and rate of sensomotor reactions. Attention features, attention span and concentration were studied as a result of correction test [7]. Rate of sensomotor reactions which were evaluated using modified Schulte tables [7]. All research methods were carefully standardized.

Statistical analysis of the results was performed using computer software Microsoft Excel and Statistica 5.5 (Multiple Regression) using the methods of variation statistics, correlation, regression, multiple correlation and regression analysis. Values at $p<0.05$ were considered to be reliable.

Results of the research and their discussion

As a result of clinical examination, increase in thyroid-stimulating hormone (TSH) over 5 μIU/mL was observed in the blood serum of children of the main group serving as a diagnostic criterion for evaluation of latent forms of hypothyroid [6, 8]. However, the content of T3, T4 and fT4 in pupils' serum was within the physiological norm according to age [3] (Table 1). The results of thyroid profile were the cause for the statements about the development of latent hypothyroidism in the examined children [6, 8]. The obtained changes in the pituitary-thyroid axis indices were observed on the background of decrease in ioduria median (Table 1). According to the data of urine with iodine excretion, severe iodine deficiency was detected in 18.4% of children, moderately severe iodine deficiency was observed in 42.1 % of children, mild iodine deficiency was found in 39.5 % of the examined patients of the main group.

Iodine content in urine was within the physiological norm in the majority of healthy peers indicating the proper intake and absorption of iodine in the body of these children [6, 8]. Decrease in

iodine concentration in urine in 28.9% of healthy children can make it possible to refer them to the risk group concerning the proper iodine supply and requires constant monitoring of thyroid homeostasis.

Table 1

Indices of thyroid system in children with latent hypothyroidism and healthy peers (M + m) living in endemic region

Age grous	T_3, nM/L	T_4, nM/L	fT_4, nM/L	TSH, μIU/mL	Ioduria median, μg /l
Group I (8-10 years of age)					
Main group (n=12)	2.70±0.25	84.19±4.27*	16.23±1.32*	5.11±0.16	89.35±12.79*
Control group (n=44)	3.01±0.48	110.18±6.23	20.31±1.08	4.80±0.29	130.25±11.44
Group II (11-14 years of age)					
Main group (n=14)	1.89±0.22* p_{1-2}<0.05	79.21±5.81*	10.67±1.11* p_{1-2}<0.05	5.20±0.22*	65.40±13.43*
Control group (n=67)	2.55±0.31	98.44±4.75	19.29±1.25	3.23±0.81	141.16±12.51
Group III (15-17 years of age)					
Main group (n=12)	1.93±0.06* p_{1-3}<0.02	68.73±6.37*	9.09±1.08* p_{1-3}<0.01	7.68±0.24* p_{1-3}<0.001 p_{2-3}<0.001	52.18±13.70*
Control group (n=65)	2.69±0.28	92.33±6.45	18.95±1.43	3.67±0.74	219.74±12.65 P_{1-3}<0.001 P_{2-3}<0.001

Note. * - here and in the following tables the difference is significant compared with the same indices in the healthy children (p<0.05); p with Arabic numerals – significant difference between the relevant age groups.

According to the results of correction test (Table 2), precision score of work performed (K, measured by the number of errors) in accordance with average data significantly decreased by 11.5 – 21.6% (p<0.001) in children of different age of the main group in comparison with the same indices in healthy pupils. Children of the intact region made fewer mistakes at testing; their pace of work remained persistently high during 5 minutes. Attention span (V) in the main group was lower by 15.4-29.1% (p<0.001). Analysis of this index dynamics showed that it had increased by 3rd-4th minute of the research and decreased on the 5th minute characterizing the mental responses inertia and rapid development of fatigue. However, attention span of healthy peers remained persistently high during 5 minutes of testing. It should be noted that increase in attention span of pupils in the control group was observed on the 2nd-3rd minute indicating quick warming-up of these children. Information analysis rate (C) in children with iodine deficiency had a clear downward trend on the 5th minute of the test and was lower in the pupils of all age groups by 25.2-33.0% (p<0.001) compared with the similar average data in the control group.

The same ratio was observed as a result of rate of sensomotor reactions and attention features study using modified Schulte tables (Table 3). The amount of numbers found by children with latent hypothyroidism according to age groups was found to decrease by 10.8 – 28.6 % (p<0.001) in

comparison with the control data. Pupils of the main group found the numbers unevenly during the test indicating the attention lability, decrease in its concentration.

Table 2

Indices of correction test (precision score of work performed (K), attention span (V), information analysis rate (C)) in children diagnosed with latent hypothyroidism and healthy peers living in endemic regions (M + m)

Age groups	Index	Minutes					Average value for 5 minutes
		1st	2nd	3rd	4th	5th	
Group I (8-10 years of age)							
Main group	K	0.65±0,05	0.61±0,06	0.55± 0,.7	0.57± 0.04	0.58±0.05	0.59±0.02*
(n=12)	V	100.31±7,31	110.44±9,45	125.69±11.01	97.13±7.05	102.69±6.95	107.25±5.11*
	C	27.16±2,51	28.04±2,97	29.15±3.01	27.67±3.15	22.95±2.42	26.99±1.07*
	K	0.81± 0,05	0.71±0,07	0.73±0.04	0.75± 0.07	0.73± 0.05	0.74±0.02
Control group	V	125.72±11,58	150.27±13.02	175.18±9.41	152.40±9.57	154.19±13.06	151.55±7.86
(n=44)	C	35.61±3,91	40.72±4.16	42.57±4.11	38.30±2.91	37.89±2.63	39.02±1.20
Group II (11-14 years of age)							
Main group	K	0.80± 0.07	0.72±0.05	0.75± 0.06	0.75± 0.07	0,63 ± 0,04	0.73±0.03*
(n=14)							p_{1-2}<0.01
	V	100.04±9.91	110.21±8.78	125.19±7.68	97.18±8.01	102,14±9,11	106.95±5.05*
	C	30.65±3.21	32.16±2.95	29.17±2.40	28.11±3.12	25,16±3,28	29.05±1.19*
	K	0.92±0.08	0.90±0.07	0.85± 0.06	0.87± 0.07	0,80± 0,05	0.87±0.02
Control group	V	175.32±12.09	200.19±12.27	205.42±8.09	185.73±8.69	160,98±13,01	185.53±8.11
(n=67)	C	40.70±2.55	41.33±2.59	42.58± 3.07	43.22±2.88	39,51±3,17	41.47±0.66
Group III (15-17 years of age)							
Main group	K	0.80±0.05	0.81±0.06	0.75± 0.07	0,73±0,05	0.25±0.06	0.77±0.03*
(n=12)							p_{1-3}<0.001
	V	185.67±10.53	189.71±9.28	200.24±8.16	205,91±7,13	180.17±12.32	192.34±4.72*
							p_{1-3}<0.01
							p_{2-3}<0.01
Control group	C	35.19±2.18	32.47±2.21	31.91±1.98	38,36±3,01	30.67±2.85	33.72±1.38*
(n=65)	K	0.91± 0.07	0.88 ± 0.06	0.85±0.07	0,83± 0,04	0.87± 0.05	0.87±0.01
	V	225.12±14.15	240.20±14.01	230.54±9.16	225,50±1,07	215.15±15.01	227.30±4.08
	C	42.75±2.65	48.54±2.57	43.16±3.12	45,11±3,50	45.89±2.90	45.09±1.04

Direct average correlative relationship between TSH content and K (r=0.35, $p<0.05$), V (r=0.29, $p<0.05$) and weak relationship between TSH content and C (r=0.32, $p<0.05$) was detected. Inverse average correlative relationship between fT_4 and K (r=-0.34, $p<0.05$), T_3 and V (r=-0.31, $p<0.05$) and T_3 and C (r=-0.29, $p<0.05$) as well as iodine content in urine and K (r=-0.33, $p<0.05$) was observed.

Conclusions

Iodine deficiency causes mental responses inertia, decrease in attention span and its concentration, slows the rate of sensomotor reactions in school children. Such influence is confirmed by the presence of correlative relationship between the indices of correction test, sensomotor reactions and the data of children thyroid status. The proposed methods of psychophysiological development status study are available for mass screening tests of pupils (including by school

psychologists) in order to identify children with possible iodine supply disorder and changes in functional ability of the thyroid gland.

Table 3

Indices of sensomotor reactions rate and attention features (the amount of found numbers using modified Schulte tables) in children diagnosed with latent hypothyroidism and healthy peers living in endemic regions (M + m)

Age groups	Tables					Average value of 5 tables
	1st	2nd	3rd	4th	5th	
Group I (8-10 years of age)						
Main group (n=12)	10.29±0.81	13.47±0.79	11.69±0.82	12.34±0.98	14.93±0.89	12.54±0.79*
Control group (n=44)	15.11±0.92	17.32 ±0.75	20.18±0.84	16.64±0.91	18.29±0.78	17.51±0.85
Group II (11-14 years of age)						
Main group (n=14)	15.98±0.85	18.16±0.78	17.64±0.91	16.75±0.76	17.01±0.81	17.39±0.63* p_{1-2}< 0.001
Control group (n=67)	20.21±0.94	21.37±0.79	20.97±0.88	22.04±0.90	21.75±0.82	21.27±0.32 p_{1-2}< 0.001
Group III (15-17 years of age)						
Main group (n=12)	20.05±0.86	21.11±0.89	21.61±0.73	22.01±0.77	20.02±0.86	21.29±0.32* p_{1-3}< 0.001 p_{2-3}< 0.001
Control group (n=65)	24.27±0.69	23.87±0.71	23.98±0.65	24.24±0.72	22.97±0.80	23.87±0.23 p_{1-2}< 0.001

Prospects for further research involve the study of the dynamics of changes in cognitive functions under the conditions of thyroid homeostasis correction with iodine medication.

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