

Research Article

Frequency and Spectrum of Chromosomal Aberrations, Acrocentric Chromosome Associations Among Long Livers with Arterial Hypertension and Osteoarthritis Residing in the Carpathian Region

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Abstract

To maintain thyroid homeostasis, a key role is played not only by the adequate provision of a body with iodine, but also with other essential micronutrients, iron in particular. Iron is involved in the conversion of the amino acid L-phenylalanine into L-tyrosine, which is the part of active center of thyroid peroxidase which catalyzes the reactions of oxidation and organification of iodine during the biosynthesis of thyroid hormones. At the same time, insufficient secretion of thyroid hormones leads to mucinous edema of the gastric mucosa and closure of its ductless glands and reduction in both gastric juice secretion and iron absorption.

The objective of the research was to determine the influence of latent iron deficiency onto the thyroid status of schoolchildren.

Materials and methods. The study involved 68 boys and 65 girls at the age 6-11 years (Group I) and 12-18 years (Group II). To assess iron metabolism, the levels of hemoglobin in capillary blood, serum iron and ferritin, serum iron binding capacity were determined. To clarify the thyroid status in blood serum samples, there were determined the content of free triiodothyronine and thyroxine, thyroid-stimulating hormone of adenohipophysis, urinary iodine concentration; the dimension of the thyroid gland was determined and evaluated considering gender as well as body surface area according to the standards of thyroid volume (97 percentile).

Results. It was established that latent iron deficiency can cause thyroid homeostasis disorders, as indicated by the growth of TSH in blood serum of girls by 37.5% ($p < 0.01$) as compared to the control data. The probability of the formation of thyroid dysfunction significantly increases in case of combined iodine and iron deficiency. The development of subclinical hypothyroidism was established in 90.0% of boys and 89.0% of girls at the age of 6-11 years and 100.0% of boys and 75.0% of girls at the age of 12-18 years with mild iodine deficiency and latent iron deficiency. In schoolchildren with microelementosis, an increase in the thyroid gland was revealed in 66.6% of boys and 75.0% of girls of Group I and in half of boys and girls of Group II.

Conclusions. Iron deficiency can cause changes in thyroid homeostasis even at the stage of preclinical disorders. Latent iron deficiency potentiates the development of subclinical hypothyroidism in case of mild iodine deficiency.

Keywords

children, thyroid status, latent iron deficiency, mild iodine deficiency

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Problem statement and analysis of the recent research

The prevalence of thyroid disease in Ukraine determines its priority among medical and social problems of medicine. In recent years, the study of the effect of essential micronutrients (iron, selenium, zinc and others) on the thyroid status has been topical [1-3]. In addition, there is a close relationship between nutrients: vitamins, micro- and macroelements. They have a strong mutual influence on the level of absorption in the gastrointestinal tract, transport and metabolic reactions. The excess or lack of one of them may be accompanied by absorption disorders or the abnormalities in the realization of

their physiological effects [1-3]. Iodine is one of the main substrates for the synthesis of thyroid hormones, which are responsible for the activity of metabolic processes in the human body. To include a trace element into the synthesis of thyroid hormones, a key role is played not only by the adequate provision of a body with iodine, but also with other essential micronutrients, iron in particular. Iron is involved in the conversion of the amino acid L-phenylalanine into L-tyrosine, which is the part of active center of thyroid peroxidase which catalyzes the reactions of oxidation and organification of iodine in the process of biosynthesis of triiodothyronine (T_3) and thyroxine (T_4). At the same time, insufficient secretion of thyroid hormones leads to mucinous edema of the gastric

mucosa and closure of its ductless glands and reduction in both gastric juice secretion and iron absorption [2, 3]. The study of thyroid status peculiarities in preclinical disorders of iron metabolism is noteworthy.

The objective of the research was to determine the influence of latent iron deficiency onto the thyroid status of schoolchildren.

1. Materials and methods

To study the thyroid status, there were examined 133 apparently healthy children (68 boys and 65 girls), who were divided into two groups according to age: Group I (n=68) included schoolchildren at the age of 6-11 years, Group II (n=65) included children at the age of 12-18 years. Each age group was divided into four subgroups: subgroup I - boys and girls with an adequate iodine and iron supply (the control group), subgroup II - pupils with mild iodine deficiency (the comparison group) [3], subgroup III - pupils with latent iron deficiency [4], subgroup IV – children with combined iodine and iron deficiency (mild iodine deficiency and latent iron deficiency).

To assess iron metabolism, hemoglobin concentration (Hb) in capillary blood, serum iron (SI) and ferritin (SF) levels, serum iron binding capacity (SIBC) were determined [4, 5]. To clarify the thyroid status in blood serum samples, there were determined the content of free triiodothyronine (fT₃) and thyroxine (fT₄), thyroid-stimulating hormone (TSH) of adenohypophysis, urinary iodine concentration [3, 7]. The dimensions of the thyroid gland were evaluated using ultrasound scanning device “ULTIMA PRD-30” (7.5 MHz, 40 mm linear array probe) with subsequent calculation of its volume according to the traditional formula proposed by J. Brunn et al. [3, 7]. The results were evaluated considering gender and body surface area according to the standards of thyroid volume (97 percentile) [3].

Statistical analysis of the received data was performed using mathematical software package Statistica 7.0 and Student's t-test.

2. Results and Discussion

There were revealed no significant changes in the indicators of iron metabolism in schoolchildren with mild iodine deficiency of Group I as compared to the control group (Table 1).

In Group II, a decrease in serum iron levels by 20.3% ($p_{1-2}<0.05$) in boys and by 18.9% ($p_{1-2}<0.05$) in girls as compared to the similar indicators in the control subgroup was observed (Table 2).

In children with latent iron deficiency (subgroup III and subgroup IV of Group I), the decrease in the levels of hemoglobin in capillary blood by 12.6-14.2% ($p_{1-3}<0.05$, $p_{1-4}<0.05$) was observed as compared to the data in the control group. These changes were associated with a decrease in SI (by 40.0-54.6%, $p_{1-3}<0.01$, $p_{1-4}<0.01$), SF (by 24.3-69.0%, $p_{1-3}<0.05$, $p_{1-4}<0.05$) on the background of SIBC increase (by 24.3-40.1%,

$p_{1-3}<0.05$, $p_{1-4}<0.05$) as compared to the control values. A similar trend was observed in Group II.

The analysis of thyroid status indicators established the reference data of the concentration of thyroid hormones in all examined schoolchildren regardless of age and gender (Table 1, 2). At the same time, the concentration of TSH in blood serum of 77.8% of boys and 77.8% of girls at the age of 6-11 years as well as in 87.5% of boys and 75.0% of girls at the age of 12-18 years with mild iodine deficiency ranged from 2.5 to 10 IU/l. These data indicated the development of subclinical hypothyroidism [6]. In schoolchildren with latent iron deficiency, all indicators of thyroid homeostasis were within physiological limits according to their age. In children with combined microelement imbalance (mild iodine deficiency and latent iron deficiency), the development of subclinical hypothyroidism was found in 90.0% of boys and 89.0% of girls at the age of 6-11 years and 100.0% of boys and 75.0% of girls at the age of 12-18 years.

The comparative analysis revealed a reduction in the levels of fT₃ by 18.5-19.9% ($p_{1-2}<0.05$, $p_{1-4}<0.05$) and fT₄ - by 14.9-20.8% ($p_{1-2}<0.05$, $p_{1-4}<0.05$) in the examined children of subgroup II and subgroup IV of Group I as compared to healthy children of the same age (Table 1). In Group II, there was revealed a decrease in the levels of fT₃ in boys of subgroup II and subgroup IV by 18.1% ($p_{1-2}<0.05$) and 16.3% ($p_{1-4}<0.05$), respectively and the levels of fT₄ decreased by 9.9% ($p_{1-2}<0.05$) and 11.0% ($p_{1-4}<0.05$) as compared to the control data (Table 2). In schoolchildren of these subgroups at the age of 6-11 years, an increase in serum level of TSH by 2.0-2.7 times ($p_{1-2}<0.01$, $p_{1-4}<0.001$) was observed; in schoolchildren at the age of 12-18 years, an increase in serum level of TSH by 73.4-88.1% ($p_{1-2}<0.01$, $p_{1-4}<0.001$) was seen as compared to the control values. Serum levels of TSH in girls at the age of 6-11 years with an adequate iodine supply on the background of latent iron deficiency (subgroup III) increased by 37.5% ($p<0.01$) as compared to the control data. These results may indicate the probability of thyroid homeostasis disorder in case of iron deficiency.

When analyzing the indices of thyroid ultrasound in children with iodine deficiency, an increase in its dimension (total volume) was found in 40.0% of boys and 33.0% of girls at the age of 6-11 years and in 50.0% of boys and 37.5% of girls at the age of 12-18 years (Table 1, 2). In children with mild iodine deficiency and latent iron deficiency, an increase in the dimension of the thyroid gland was found in 66.6% of boys and 75.0% of girls of Group I and in 50.0% of boys and 50.0% of girls of Group II.

3. Conclusions

Iron deficiency can cause changes in thyroid homeostasis even at the stage of preclinical disorders. The probability of the formation of thyroid dysfunction significantly increases in case of combined iodine and iron deficiency. Particularly, latent iron deficiency potentiates the development of subclinical hypothyroidism in case of mild iodine deficiency.

Table 1. Indicators of thyroid status and iron metabolism in schoolchildren at the age of 6-11 years (M±m)

Indices	Subgroup I (the control group)		Subgroup II (the comparison group)		Subgroup III		Subgroup IV	
	boys, n=8	girls, n=8	boys, n=9	girls, n=9	boys, n=8	girls, n=8	boys, n=10	girls, n=9
fT ₃ , nmol/l	3.91±0.13	3.85±0.21	3.19±0.23 p ₁₋₂ <0.05	3.21±0.11 p ₁₋₂ <0.05	3.84±0.24	3.57±0.23	3.13±0.21 p ₁₋₄ <0.05	3.16±0.20 p ₁₋₄ <0.05
fT ₄ , nmol/l	2.16±0.08	1.94±0.07	1.81±0.07 p ₁₋₂ <0.05	1.74±0.07	1.98±0.06	1.87±0.08	1.71±0.07 p ₁₋₄ <0.01 p ₃₋₄ <0.05	1.65±0.06 p ₁₋₄ <0.05
TSH, mkMO/ml	1.56±0.13	1.44±0.18	3.09±0.29 p ₁₋₂ <0.01	3.22±0.25 p ₁₋₂ <0.01	2.05±0.28	1.98±0.23 p ₂₋₃ <0.01	3.92±0.27 p ₁₋₄ <0.001 p ₃₋₄ <0.01	3.91±0.32 p ₁₋₄ <0.001 p ₃₋₄ <0.01
Volume of thyroid gland, cm ³	3.03±0.38	2.87±0.5	3.77±0.4	3.99±0.94	3.45±0.51	3.84±0.61	4.01±1.28	4.16±0.67
Hb, g/l	134.21±5.31	130.25±4.21	130.28±4.34	128.34±3.26	117.33±2.14 p ₁₋₃ <0.05 p ₂₋₃ <0.05	114.54±3.01 p ₁₋₃ <0.05 p ₂₋₃ <0.05	115.15±2.32 p ₁₋₄ <0.05 p ₂₋₄ <0.05	112.32±2.19 p ₁₋₄ <0.01 p ₂₋₄ <0.01
SI, mcmol/l	21.45±1.94	24.33±2.01	15.52±1.69	20.58±1.98	12.01±1.92 p ₁₋₃ <0.01	14.58±1.89 p ₁₋₃ <0.01	9.95±1.70 p ₁₋₄ <0.01 p ₂₋₄ <0.05	11.55±1.95 p ₁₋₄ <0.01 p ₂₋₄ <0.01
SIBC, mc-mol/l	50.89±5.03	48.9±3.59	55.23±3.86	54.36±3.56	63.28±3.02 p ₁₋₃ <0.05	64.52±5.6 p ₁₋₃ <0.05	71.31±5.32 p ₁₋₄ <0.05 p ₂₋₄ <0.05	77.46±5.65 p ₁₋₄ <0.01 p ₂₋₄ <0.01
Serum ferritin, ng/ml	56.14±8.9	51.11±4.12	45.54±6.12	43.65±5.42	34.28±3.51 p ₁₋₃ <0.05	24.8±3.67 p ₁₋₃ <0.01 p ₂₋₃ <0.05	22.68±5.21 p ₁₋₄ <0.05 p ₂₋₄ <0.05	15.86±3.93 p ₁₋₄ <0.01 p ₂₋₄ <0.01

Note.

p with Arabic numerals is the significant difference between the respective subgroups

4. Prospects for further research

Taking into account the prevalence of iron-deficiency anemia in regions of endemic goiter, the development of predictive criteria for disorders of thyroid homeostasis to improve the efficacy of preventive and therapeutic measures for schoolchildren with latent iron deficiency is promising.

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Received: 23 May 2017

Revised: 30 May 2017

Accepted: 31 May 2017

Table 2. Indicators of thyroid status and iron metabolism in schoolchildren at the age of 12-18 years (M±m)

Indices	Subgroup I (the control group)		Subgroup II (the comparison group)		Subgroup III		Subgroup IV	
	boys, n=8	girls, n=8	boys, n=9	girls, n=9	boys, n=8	girls, n=8	boys, n=9	girls, n=9
fT ₃ , nmol/l	3.86±0.11	3.73±0.24	3.16±0.25 p ₁₋₂ <0.05	3.18±0.12	3.37±0.25	3.13±0.21	3.12±0.22 p ₁₋₄ <0.05	3.11±0.19
fT ₄ , nmol/l	1.83±0.06	1.82±0.05	1.65±0.04 p ₁₋₂ <0.05	1.66±0.05	1.72±0.06	1.74±0.07	1.62±0.06 p ₁₋₄ <0.05	1.63±0.07
TSH, mkMO/ml	1.77±0.15	1.92± 0.28	3.14±0.26 p ₁₋₂ <0.01	3.34±0.29 p ₁₋₂ <0.01	1.55±0.14	2.15± 0.24	3.33±0.23 p ₁₋₄ <0.001 p ₃₋₄ <0.001	3.42± 0.31 p ₁₋₄ <0.01 p ₃₋₄ <0.05
Volume of thyroid gland, cm ³	7.81±1.41	5.66±0.37	7.71±1.6	6.61±1.72	8.91±1.12	4.92±0.81	6.82±1.02	6.67±0.68
Hb, g/l	145.32±6.37	128.25±5.24	151.23± 6.32	125.34±3.05	118.53±2.94 p ₁₋₃ <0.01 p ₂₋₃ <0.01	116.54±2.43	114.54 ±2.52 p ₁₋₄ <0.01 p ₂₋₄ <0.01	113.32±2.08 p ₁₋₄ <0.05 p ₂₋₄ <0.05
SI, mcmol/l	18.48±0.93	19.04 ±0.98	14.73±0.66 p ₁₋₂ <0.05	15.51±0.92 p ₁₋₂ <0.05	11.72±0.95 p ₁₋₃ <0.001 p ₂₋₃ <0.05	12.13±0.85 p ₁₋₃ <0.01 p ₂₋₃ <0.05	10.02±0.66 p ₁₋₄ <0.01 p ₂₋₄ <0.01	11.74±0.91 p ₁₋₄ <0.01 p ₂₋₄ <0.05
SIBC, mc- mol/l	56.75±6.41	50.64±4.12	56.71±3.49	51.72±2.96	66.05±3.53	66.32±5.11 p ₁₋₃ <0.05	69.56±4.76	68.84±5.19 p ₁₋₄ <0.05
Serum fer- ritin, ng/ml	53.71±7.45	41.45±3.07	37.95±5.92	31.81±3.45	29.92±3.51 p ₁₋₃ <0.05	23.43±4.57 p ₁₋₃ <0.05	27.32±5.01 p ₁₋₄ <0.05	21.61±3.54 p ₁₋₄ <0.01

Note.

p with Arabic numerals is the significant difference between the respective subgroups