ISSN 2509-4327 (print)
ISSN 2510-4780 (online)

Deutscher Wissenschaftsherold
German Science Herald

№ 4/2017

Die Zeitschrift „Deutscher Wissenschaftsherold" ist eine Veröffentlichung mit dem Ziel ein breites Spektrum der Wissenschaft allgemeinverständlich darzustellen. Die Redaktionsleitung versteht sich als Vermittler zwischen Wissenschaftlern und Lesern. Durch die populärwissenschaftliche Bearbeitung wird es möglich unseren Lesern neue wissenschaftliche Leistungen am besten und vollständigsten zu vermitteln. Es werden Untersuchungen, Analysen, Vorlesungen, kurze Berichte und aktuelle Fragen der modernen Wissenschaft veröffentlicht.

Impressum
Deutscher Wissenschaftsherold – German Science Herald
Wissenschaftliche Zeitschrift
Herausgeber:
InterGING
Sonnenbrink 20
31789 Hameln, Germany
Inhaber: Marina Kisiliuk
Tel.: + 49 51519191533
Fax.:+ 49 5151 919 2560
Email: info@dwherold.de
Internet:www.dwherold.de
Chefredakeur/Editor-in-chief:
Marina Kisiliuk
Korrektur:
O. Champela
Gestaltung:
N. Gavrilets

Auflage: № 4/2017 (September) – 30
Redaktionsschluss September, 2017
Erscheint vierteljährlich
Editorial office: InterGING
Sonnenbrink 20
31789 Hameln, Germany
Tel.: + 49 51519191533
Fax.:+ 49 5151 919 2560
Email: info@dwherold.de
Deutscher Wissenschaftsherold - German Science Herald is an international, German/English language, peer-reviewed, quarterly published journal.
№ 4/2017
Passed in press in September 2017
Druck: WIRmachenDRUCK GmbH
Mühlbachstr. 7
71522 Backnang
Deutschland

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INDEXING: Google Scolar, WorldCat, Index Copernicus, InfoBase Index, Journal Index, Citefactor, International Scientific Indexing, JIFACTOR, Scientific Indexing Services, International Institute of Organized Research.

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DDC-UDC 616.12-008.1+613.96+546.15+546.72 DOI:10.19221/2017417

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THE STATE OF AUTONOMOUS HEART REGULATION IN ADOLESCENTS WITH LIGHT IODINE DEFICIENCY AND LATENT IRON DEFICIENCY

Abstract. *The variability of heart rate in teenagers (12-18 years) with latent iron deficiency, light iodine deficiency, in conditions of their combination and in healthy coevals (control group) was examined. Thyroid status was characterized by the content of free triiodothyronine (fT_3) and thyroxine (T_4), thyroid-stimulating hormone of adenohypophysis (TSH), content of iodine in urine. The iron metabolism was evaluated by the content of hemoglobin in capillary blood, level of serum iron and serum ferritin, serum iron binding capacity. The development of latent hypothyroidism in girls and boys with isolated iodine deficiency, combined iodine and iron deficiency was found. A significant decreasing of hemoglobin content, serum iron and ferritin on the background of increasing the iron binding capacity of serum in examined children of 3-rd and 4-th groups to the analogical data in a healthy coevals. In children of control group a balanced influence of sympathetic and parasympathetic divisions of the autonomic nervous system was detected. In children with light iodine deficiency the intensity of mechanisms of autonomic regulation. In boyd and girls with combined deficiency of microelements the increasing of parasympathetic effects, that is shown by the rise of indexes of rMSSD (on 25.6-52.2%, $p_{1-4} < 0.05$), pNN50(%) (on 56.5-61.0 %, $p_{1-4} < 0.05$), HF (in 42.9-60.7%, $p_{1-4} < 0.05$) on the background of reduction the ratio LF/HF (on 41.6-57.6%, $p_{1-4} < 0.05$) to analogical control data. Latent iron deficiency significantly potentiates the narrowing of adaptation and reserve possibilities of organism of children with light iodine deficiency.*

Key words*: heart rate variability, light iodine deficiency, latent iron deficiency, thyroid status, iron metabolism, teenagers.*

Introduction. The main factor in the disruption of the functional capacity of the thyroid gland is iodine deficiency in the environment. In recent years, there has been an increase in the number of cases of hypothyroid pathology and its complexity is increasing [1, 8]. The reasons for this trend may be the inadequacy of preventive measures, the detection of pathology at the stages of preclinical changes and the influence of other goitrogens. It contributes to an increase in the incidence of significant man-made stress, deficiency of essential (selenium, iron) and excess of toxic (cadmium, chlorine) trace elements [4, 8]. Of particular interest is the elucidation of regulatory and adaptive capabilities of the organism at preclinical stages of microelement imbalance. The study is conducted due to the high probability of forming a combined micronutrient deficiency in the regions of goiter endemia, excessive sensitivity to trace elements in children and adolescents.

The objective of the study: to evaluate the effect of mild iodine deficiency and latent iron deficiency on the functional state of autonomic regulation in adolescents.

Materials and methods of research. Thirty-six practically healthy adolescents (33 boys and 32 girls) aged 12 to 18 years were divided into four groups: the first (n = 17) - boys and girls with the proper exchange of iodine and iron (control

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group) 2nd (n = 16) - children with mild iodine deficiency, 3rd (n = 16) - children with latent iron deficiency, 4- (n = 16) - boys and girls with mild iodine deficiency and latent iron deficiency.

The level of provision of the body with iodine was evaluated on the basis of the data of microelement excretion in urine, the median of ioduria was found [1, 4, 8]. Thyroid status was characterized by the content of free triiodothyronine (fT3) and thyroxine (fT4), the thyroid-stimulating hormone of adenohypophysis (TSH) (test kit "DRG", Germany), [1, 4, 8]. The exchange of iron was assessed by hemoglobin content in capillary blood, serum iron level, iron-binding capacity of serum (test kit "Cormay", Poland). The state of the iron depot was characterized by the level of serum ferritin (SF) (chemiluminescent method using the Immulite 2000 test system of the USA) [5]. The status of AHR in children was assessed by analyzing heart rate variability (HRV). The survey was conducted on the device "Poly-Spectrum.NET" (Neurooft, Ukraine). Studies were conducted in the morning (from 9 to 12 hours), on an empty stomach, lying down and standing after a 15-minute rest in a horizontal position (to adapt to the survey conditions). The ECG was recorded for 5 minutes. ECG data were analyzed in an automatic mode using a program to determine the spectral parameters of the heart rate according to the Heart Rate Variability, the Standards of Measurement, the Physiological Interpretation and Clinical Use, the Task Force of the European Society of Cardiology of North American Society [9]. The physiological aspects of autonomic dysfunction were evaluated by such parameters of the rhythmogram: SDNN (standard deviation of normal NN intervals), rMSSD (quadratic root of the sum of the squares of the difference in the values of the consecutive pairs of NN intervals, depends on the activity of the parasympathetic department of the ANS), pNN50% (the percentage of pairs of consecutive intervals, Which differ more than 50 ms), mode (Mo), mode amplitude (AMO), variation range (BP), voltage index (IN). Spectral analysis was performed by recording the following indices: LF (spectrum power at 0.05-0.15Hz, characterized mainly by the attractive ANS section), LFn% (low frequency wave fraction), HF (spectrum power at 0.15 -0.4Hz, reflects the activity of the parasympathetic of ANS), HFn% (fraction of high-frequency waves), LF / HF - ratio of low- and high-frequency components [9]. Studies were conducted in successive representative groups of observations. Statistical analysis of the data was carried out using the package of mathematical programs StatisticSoft 7.0. Statistically significant difference was considered when $p < 0.05$.

Results of the study and their discussion. As a result of the examination, the development of latent hypothyroidism in schoolchildren of the 2 nd and 4 th groups was diagnosed (Table 1). A significant decrease in the content of hemoglobin, serum iron and ferritin in the examined children of the 3rd and 4th groups was found with respect to similar data in healthy peers (Table 1).

Members of the control group maintained a balanced influence of sympathetic and parasympathetic parts of the autonomic nervous system (ANS) in a horizontal position, disrupted when taking a vertical position (tab. 2).

In boys of the 2nd experimental group, the growth of rMSSD (47.8-56.8%, p1-2 <0.05), AMo (66.7%, p1-2 <0.05), TI (2.7 times, p1-2 <0.05), HF (43.9%, p1-2 <0.05) against the background of Mo decrease (by 14.6%, p1-2 <0.05), LF (by 41.7%, p1-2 <0.05) for similar control data (Table 3). A similar trend of changes in indicators was found when changing the position of the body (standing). Such dynamics may indicate the tension of autonomous regulation mechanisms even for children with mild iodine deficiency.

In the 3rd group survey, most of the HRV indices did not differ significantly from that of healthy peers (Table 4).

In boys and girls with combined deficiency of trace elements, an increase in parasympathetic effects was observed, as indicated by an increase in rMSSD (25.6-52.2%, p1-4 <0.05), pNN50% (by 56.5-61.0 %, P1-4 <0.05), HF (42.9-60.7%, p1-4 <0.05) against LF / HF (41.6-57.6%, p1 -4 <0,05) relative to similar control data (Table 5).

Considering the presence of significant changes between the 2nd and 4th experimental groups (Mo), the 3rd and 4th experimental groups (rMSSD, pNN50%, IH, LF, HF, LF / HF) one can clearly speak of the significant depletion of adaptation reserves under the condition of combined microelement imbalance.

Table 1

Indices of thyroid system and iron metabolism of children with mild iodine deficiency, latent iron deficiency and combined iodine and iron deficiency imbalance (M + m)

Indices	1st group (control)		2nd group		3rd group		4th group	
	Boys (n=9)	Girls (n=8)	Boys (n=8)	Girls (n=8)	Boys (n=8)	Girls (n=8)	Boys (n=8)	Girls (n=8)
Free triiodothyronine (fT3) (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
Free thyroxine (fT_4), нмоль/л	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
Thyroid-stimulating hormone (TSH), mcMO/ml	1,77± 0,15	1,92± 0,28	3,34±0,26 $p_{1-2}<0,001$	3,34±0,29 $p_{1-2}<0,01$	1,55±0,14	2,15± 0,24	3,33±0,23 $p_{1-4}<0,001$	3,42± 0,31 $p_{1-4}<0,01$
Median of ioduria, mcg/l	102,21± 4,06	102,11± 3,96	71,44±5,29 $p_{1-2}<0,01$	81,52±5,34 $p_{1-2}<0,05$	102,52±4,54	101,25±3,65	78,03± 6,75 $p_{1-4}<0,05$	72,04±6,34 $p_{1-4}<0,01$
Hemoglobin, 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 $p_{1-4}<0,05$ $p_{2-4}<0,05$
Serum iron level, 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 $p_{1-4}<0,01$ $p_{2-4}<0,05$
Iron-binding capacity, mcmol/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 ferritin (SF), 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: here and in the following tables p with Arabic numerals is the likely difference between the respective groups.

Table 2

Indices of cardiac rhythm variability for healthy school-age children (M + m)

Indices	1st group (control)			
	Boys n=8		Girls n=8	
	In lying position	In vertical position	In lying position	In vertical position
SDNN, ms	70.51±5.21	117.52±4.36*	70.53±3.52	95.32±2.36*
rMSSD,msc	68.23±7.72	36.21±4.23*	52.52±5.36	62.56±6.23
pNN50, %	7,74±0.51	8.520.82	6,81±1.16	8.080,38
Mode (Mo), s	0,85±0,07	0,48±0,02*	0,82±0,04	0.63±0,04*
Mode amplitude (Амо), %	34,57±2,71	61,69±6,82*	24,51±3,45	35,23±3,51
Range (Dx), s	0,36±0,03	0,27±0,04	0,37±0,06	0,34±006
Tension index (TI), st. unit	49,22±4,51	195,21±11,35*	44,12±8,24	112,64±24,16*
0.04-0.15 Hz LF, ms	1011,43±95,15	2554,33±415,33*	1233,24±130,12	1591,23±154,32
0.04-0.15 HzLF, %	37,25±3,34	71,25±4,15*	43,53±4,23	69,06±5,61*
0.15-0.4 Hz HF, ms	1003,11±101,26	524,34±57,86*	761,89±50,46	519,32±24,12*
0.15-0.4 Hz HF, %	43,62±4,02	21,73±2,04*	36,63±3,82	22,71±2,43*
LF/ HF ratio	1,13±0,19	4,77±0,64*	1,03±0,12	4,01±0,9*

*Note: here and in the following tables * is the likely difference between the respective groups.*

Table 3

Heart rate variability indices for school-age children with mild iodine deficiency (M + m)

Indices	**2nd group (children with the mild iodine deficiency)**			
	Boys n=8		Girls n=8	
	In lying position	In vertical position	In lying position	In vertical position
SDNN, ms	80.23±3.49	104.62±9.69*	87.37±3.94 $p_{1-2}<0,05$	104.62±10.89
rMSSD, ms	81.52±8.23	53.52±5.23* $p_{1-2}<0,05$	70.23±6.74	45.37±3,23* $p_{1-2}<0,05$
pNN50, %	8,74±0.82	9,41±1,04	7,21±0.81	8,35±0.91
Mode (Mo), s	0,87±0,07	0,57±0,06*	0,70±0,02 $p_{1-2}<0,05$	0,51±0,03* $p_{1-2}<0,05$
Mode amplitude (Амо), %	33,56±4,51	45,91±5,34	40,85±4,13 $p_{1-2}<0,05$	55,15±6,21 $p_{1-2}<0,05$
Range (Dx), s	0,41±0,05	0.20±0,03*	0,30±0,06	0,19±0,02 $p_{1-2}<0,05$
Tension index (TI), st. units	62,12±5,51	155,33±45,52*	121,31±31,71 $p_{1-2}<0,05$	264,37,±44,36* $p_{1-2}<0,05$
0.04-0.15 Hz LF, ms	897,11±83,56	1788,63±235,34*	719,23±98,23 $p_{1-2}<0,05$	1068,42±176,63 $p_{1-2}<0,05$
0.04-0.15 Hz LF, %	40,51±3,82	72,51±3,71*	49,38±4,43	74,32±2,64*
0.15-0.4 Hz HF, ms	1397,21±132,23 $p_{1-2}<0,05$	488,84±55,43*	1096,42±130,25 $p_{1-2}<0,05$	525,21±30,61*
0.15-0.4 Hz HF, %	50,56±,5,22	19,21±1,92*	47,23±4,52	18,05±1,42*
LF/ HF ratio	0,77±0,1	3,23±0,43*	0,72±0,08	3,38±0,32*

Table 4

Indices of heart rhythm variability for school-age children with latent iron deficiency (M + m)

Indices	3rd group (children with latent iron deficiency)			
	Boys n=8		Girls n=8	
	In lying position	In vertical position	In lying position	In vertical position
SDNN, ms	71.81±6.81	120.23±12.72*	80.17±9.02	100.639.12
rMSSD, ms	40.63±4.91 p_{1-3}<0,05	42.56±3.56	37.67±4.76 p_{2-3}<0,01	38.81±3.21 p_{1-3}<0.01
pNN50, %	7.320.78	7.890.69	6.330.62	7.180.72
Mode (Mo), s	0,85±0,09	0,60±0,08	0,73±0,04	0,57±0,05*
Mode amplitude (Amo), %	30,45±4,13	46,72±5,32*	34,80±5,04	46,65±3,91
Range (Dx), s	0,44±0,07	0,39±0,06	0,27±0,04	0,38±0,03
Tension index (TI), st. units	37,24±4,42 p_{2-3}<0,01	168,58±13,54*	66,61±8,53	129,01±10,29* p_{2-3}<0,05
0.04-0.15 Hz LF, ms	1003,25±170,24	1696,61±149,22*	924,25±92,12	1456,12±115,31*
0.04-0.15 Hz LF, %	44,55±3,24	48,52±5,25 p_{1-3}<0,05	45,21±3,71	53,24±6,32
0.15-0.4 Hz HF, ms	1133,32±123,74	484,25±31,01*	641,42±60,21 p_{2-3}<0,05	677,52±61,36* p_{1-3}<0,05
0.15-0.4 Hz HF, %	46,52±3,53	23,75±3,61*	38,46±3,23	32,64±3,31 p_{1-3}<0,05
LF/ HF ratio	0,85±0,11	3,49±0,48*	1,60±0,23 p_{2-3}<0,05	5,81±0,86*

Table 5

Indices of heart rhythm variability for school-age children with mild iodine deficiency and latent iron deficiency (M + m)

Indices	4th group (mild iodine deficiency and latent iron deficiency)			
	Boys n=8		Girls n=8	
	In lying position	In vertical position	In lying position	In vertical position
SDNN, ms	86.81±6.81	102.23±12.32	102,52±13,02 p_{1-4}<0,05	123.75±12.13 p_{1-4}<0,05
rMSSD, ms	85.74±8.43 p_{3-4}<0,01	55.11±4.81* p_{1-4}<0,05	72.51±6.32 p_{1-4}<0,05 p_{3-4}<0,01	44,23±4.62* p_{1-4}<0,05
pNN50, %	12,46±1.92 p_{1-4}<0,05 p_{3-4}<0,05	9,89±0,91	10,66±0.42 p_{1-4}<0,05 p_{3-4}<0,001	12.43±1,39 p_{1-4}<0,05 p_{3-4}<0,01
Mode (Mo), s	0,66±0,04 p_{1-4}<0,05 p_{2-4}<0,05	0,61±0,05 p_{1-4}<0,05	0,64±0,04 p_{1-4}<0,05	0,50±0,04* p_{1-4}<0,05
Mode amplitude (Амо), %	43,35±5,25	62,61±4,85*	38,52±4,04 p_{1-4}<0,05	49,56±5,12 p_{1-4}<0,05
Range (Dx), s	0,58±0,08 p_{1-4}<0,05	0,41±0,06 p_{1-4}<0,05 p_{2-4}<0,05	0,28±0,05	0,22±0,04

Таблиця №5 (продовження)

Tenstion index (TI), st. units	67,73±6,53* p_{1-4}<0,05 p_{3-4}<0,01	149,81±16,05* p_{1-4}<0,05	142,59±29,16 p_{1-4}<0,05 p_{3-4}<0,05	189,92±19,01 p_{1-4}<0,05
0.04-0.15 Hz LF, ms	849,23±70,24	1185,36±159,25 p_{1-4}<0,05 p_{3-4}<0,05	804,25±96,23 p_{1-4}<0,05	1013,36±141,64 p_{1-4}<0,05 p_{3-4}<0,05
0.04-0.15 Hz LF, %	45,26±4,92	56,34±2,21 p_{1-4}<0,05	52,72±3,46	72,28±6,62*
0.15-0.4 Hz HF, ms	1433,75±128,74* p_{1-4}<0,05	534,71±60,13*	1224,42±108,54* p_{1-4}<0.01 p_{3-4}<0,01	503,52±51,12*
0.15-0.4 Hz HF, %	53,16±4,91	30,66±2,14* p_{1-4}<0,05 p_{2-4}<0,01	49,84±4,03 p_{1-4}<0,05	20,64±2,14*
LF/ HF ratio	0,66±0,07 p_{1-4}<0,05	2,41±0,44* p_{1-4}<0,05	0,69±0,07 p_{1-4}<0,05 p_{3-4}<0,01	1,70±0,12* p_{1-4}<0,05 p_{3-4}<0,01

Conclusions. Deficiency of iodine results in disturbances of autonomic regulation of the heart. Latent iron deficiency significantly potentiates the narrowing of the adaptive and reserve capacities of the schoolchildren with mild iodine deficiency.

Prospects for further research. Investigation of the dynamics of indicators of HRV with age, possibilities of restoration of adaptation reserves of pupils in conditions of therapy with trace elements.

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№ 4/2017 – 30
Passed in press in September 2017