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ПОРІВНЯЛЬНА ОЦІНКА ВМІСТУ У КРОВІ ГОМОЦИСТЕЇНУ, ГОРМОНІВ ТА МІНЕРАЛІВ У ДІТЕЙ З РІЗНИМ РІВНЕМ ФІЗИЧНОГО РОЗВИТКУ, ЯКІ ПРОЖИВАЮТЬ ПОБЛИЗУ ЧОРНОБИЛЬСЬКОЇ ЗОНИ ВІДЧУЖЕННЯ

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COMPARATIVE ASSESSMENT OF BLOOD LEVELS OF HOMOCYSTEINE, HORMONES AND MINERALS IN CHILDREN WITH DIFFERENT LEVELS OF PHYSICAL GROWTH LIVING NEAR THE CHORNOBYL EXCLUSION ZONE

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Studies carried out in 2013-2017, within projects of the European Commission «Health and Ecological Programmes around the Chornobyl Exclusion Zone: Development, Training and Coordination of Health-Related Projects» and the Rhфne-Alpes Regional Council (France) have shown changes in metabolism in children living in Ivankivskyi and Polisskyi districts of Kyiv region, bordering the Chornobyl Exclusion Zone. In particular, a large number of adolescents have been found to have increased blood levels of a sulfur-containing amino acid homocysteine, a metabolite of an essential amino acid methionine [1]. We identified associations between blood concentrations of calcium, phosphorus and hormones that regulate mineral metabolism, taking into account the state of the genetic system of the folate cycle [2-4].

The purpose of the study was a comparative assessment of blood levels of homocysteine, hormones and minerals in children with different levels of physical growth living in settlements near the Chornobyl exclusion zone.

Material and methods. The study was conducted within the implementation of the projects of the European Commission in Ukraine «Health and Ecological Programmes around the Chornobyl Exclusion Zone: De-

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***Мета дослідження:** порівняльна оцінка вмісту у крові гомоцистеїну, гормонів і мінералів у дітей з різним рівнем фізичного розвитку, які проживають у населених пунктах поблизу Чорнобильської зони відчуження.*
***Методи дослідження:** інструментальний, лабораторний, математико-статистичний.*
***Результати**. У рамках виконання в Україні проектів Європейської комісії «Оздоровчі та екологічні програми, пов'язані з Чорнобильською зоною відчуження. Підготовка, навчання і координація проектів з охорони здоров'я» та Регіональної Ради Рон-Альп (Франція) обстежено 158 дітей (78 хлопчиків і 80 дівчаток) з Поліського району Київської області. Досліджувана територія донині залишається радіоактивно забрудненою після аварії на ЧАЕС. Показано, що інкорпорація ^{137}Cs в організм негативно впливає на фізичний розвиток (ФР) дітей. Радіонукліди ^{137}Cs викликають порушення клітинної енергетики, негативно впливають на гормоногенез щитоподібної залози. Встановлено достовірно високий рівень трийодтироніну вільного (T_3), паратиреоїдного гормону (ПТГ) і Р у підлітків з дисгармонійно низьким ФР порівняно з дітьми, які мають дисгармонійно високий ФР. Кореляційні зв'язки між показниками ФР, ендокринної системи та мінерального обміну, зареєстровані у групі обстежених дітей, відображають фізіологічну відповідь організму на пошкодження клітин, що пов'язане з впливом радіонуклідів ^{137}Cs. Співставлення значень окремих метаболічних показників обміну речовин з референтними значеннями не завжди об'єктивно відображає тяжкість порушень обміну речовин. Для визначення порушень обміну речовин в умовах постійної інкорпорації радіонуклідів ^{137}Cs в організмі дитини необхідно використовувати інформацію про зв'язки між декількома метаболічними показниками у групі дітей, які проживають на території, що постраждала від аварії на Чорнобильській атомній електростанції.*

Ключові слова: гомоцистеїн, гормони, кальцій, фосфор, індекс Рорера, підлітки, радіоактивно забруднені території.

velopment, Training and Coordination of Health-Related Projects» and the Rhфne-Alpes Regional Council (France). 158 children (78 boys and 80 girls) from Polisskyi district, Kyiv region, underwent laboratory and instrumental examination. According to data of dosimetry certification of settlements, the territory of the district has remained contaminated with radioactive substances after the Chornobyl accident until the present day (a ^{137}Cs soil contamination density varies from 0.17 Ci/sq.km to 1.9 Ci/sq.km [5]).

All the examined children who attended school had blood drawn from the ulnar vein after fasting in the morning on 02.04.2015. At the time of examination the average age of the children was (14.8 ± 0.1) years (95% CI 14.7-15.0 years)

The blood samples were analysed at a laboratory certified under quality standards with the agreement of the parents. We measured blood levels of homocysteine (H_{cy}), ionized calcium (Ca), phosphorus (P), parathyroid hormone (PTH), calcitonin (CT), thyroglobulin (Tg), pituitary thyroid-stimulating hormone (TSH), free triiodothyronine (T_3), free thyroxine (T_4), cortisol (Cort).

Blood H_{cy} concentrations were measured using a chemiluminescent immunoassay (CLIA) method. Analyzer and test kit: Architect 1000 (ABBOT Diagnostics, USA). The blood Hcy level in children of more than 10 μmol/L was defined as hyperhomocysteinemia.

Ca levels were measured using an ion-selective method. Analyser and test kit: AVL 9180; Roche Diagnostics (Switzerland). Reference values: 1.16-1.32 mmol/L.

P was determined using a spectrophotometric method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values: for boys 0.95-1.65 mmol/L, for girls – 0.90-1.55 mmol/L.

PTH was measured using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 15.0-65.0 pg/ml.

T_3 levels were determined using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 2.3-5.0 pg/ml.

T_4 levels were measured using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 1.1-1.8 ng/dl.

Tg levels were determined using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 3.5-77.0 ng/ml.

TSH was measured using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 0.27-4.2 mIU/mL.

CT concentrations were measured using a chemiluminescent immunoassay (CLIA) method. Analyser and test kit: Immulite (Siemens AG), Germany. Reference values — up to 11.5 pg/ml.

Cort levels were determined using an electrochemiluminescent immunoassay (ECLIA) method. Analyser and test kit: Cobas 6000, Roche Diagnostics (Switzerland). Reference values – 6.2-19.4 μg/dL.

Physical growth (PG) in children was assessed with the help of anthropometric measuring techniques standardised in Ukraine in compliance with the rules of bioethics and signing protocols of informed consent of parents for each subject [6].

The Rohrer's weight/height index (RI), independent on age and gender, calculated by dividing weight in kilograms by the cubic of height in meters, was chosen as a criterion for assessment of PG and metabolism in a child [7, 8].

RI allows to estimate the degree of weight and height conformity of an individual. Normal PG is defined at RI values of 10.7 kg/m^3 to 13.7 kg/m^3, abnormal PG in children with insufficient body weight is defined at RI values of less than 10.7 kg/m^3, and abnormal PG in children with excessive body weight is defined at RI values of more than 13.7 kg/m^3. Three subgroups were identified according to RI values during the examination of children from Polessky district:

«1» – abnormal (low) PG, RI < 10.7 (n = 17).

«2» – normal PG, RI is in the range of $\leq$ 13.7 and $\geq$ 10.7 (n = 103).

«3» – abnormal (high) PG, RI > 13.7 (n = 38).

Specific activity of gamma-emitter radionuclides (^{137}Cs) was measured in a body of children using a three-detector whole-body counter (SICh, WBC) manufactured by AtomKompleksPribor (Ukraine).

The statistical processing of the results obtained was performed using the IBM SPSS Statistics 22 software (USA). The arithmetic mean (*M*), standard error of mean (*m*), confidence interval for the mean

value (*95% CI*), median (*Me*), interquartile range (*IQR*), minimum and maximum parameter values and percentiles were calculated for the variables analysed. The distribution hypothesis (a Kolmogorov-Smirnov test) was tested. All the parameters under study did not conform to the normal distribution law, thus, a non-parametric Mann-Whitney U-test was used to compare values. The statistical significance of variables was assessed by determining a significance level for p with the help of the statistical software programme.

The Student's t-test was used to compare relative values. The critical level of significance for the null hypothesis (p) was set at 0.05. Associations between values of RI, ^{137}Cs specific activity in a body, blood H_{cy}, Tg, TSH, T_3, T_4, PTH, Cort, CT, P, Ca and a T_3/T_4 index were identified with the help of the Spearman's rank correlation coefficient (r_{xy}). The strength of an association was assessed according to a typical scale: weak – 0 to 0.299; moderate – 0.3 to 0.699; strong – 0.7 to 1.0.

Results and their discussion. The specific activity of ^{137}Cs radionuclides in the children from Groups 1 and 2 was statistically significantly higher than in the children from Group 3 (tables 1-4). There were no statistical differences between the groups in relation to the relative number of cases of falling outside of the reference values (RV) of the analyzed metabolic variables (table 5). This, in particular, regards to the relative number of cases of hyperhomocysteinemia (about 50% of the number of children in each group).

The blood levels of H_{cy}, TSH, T_4, Cort, Tg, Ca, CT, as well as the values of the T_3/T_4 index did not differ statistically in the groups (tables 1-4).

Statistical differences between the studied groups of children with different PG levels related to blood PTH, P and T_3. The blood level of PTH and P was statistically significantly higher in children in the Group 1 than in those in the Groups 2 and 3 (tables 1-3). It was also found that the blood T_3 concentration in children in the Group 1 exceeded that in children from the Group 3 (tables 1, 3). There were no statistical differences in values of the analyzed variables between the Groups 2 and 3 (tables 1, 4).

Correlation analysis confirmed this relationship, in the total group of children RI had inverse associations with T_3, PTH and P, as well as with CT (table 6).

PTH and P were linked by a moderate direct association. Direct associations were also found between T_3 and PTH, T_3 and P (table 6).

Physiological relationships were established between the hormones of the pituitary gland and the thyroid gland, in which TSH had an inverse association with T_4 and a direct association with T_3, which is also evidenced by the associations of hormones with a T_3/T_4 index. In the total group, Tg was not associated with RI and analysed metabolic variables. However, in the Group 1, there was a strong inverse association between this metabolite and ^{137}Cs (Spearman's coefficient = -0.721**, p = 0.001, n = 17). Ca had no associations with PTH and P; however, a stable strong direct association was reported between Ca and H_{cy}.

The studies showed that the ^{137}Cs activity in a human body has an inverse association with PG values of children living in the territory affected by the accident at the Chornobyl nuclear power plant. At the same time, it should be noted that the age of the examined adolescent children had no associations with RI [9].

Taking into account the results of previous studies [10-13], it can be reasonably stat-

Table 1

Statistical variables of children with different levels of physical growth

Variables	Total group		Group 1		Group 2		Group 3	
	Me	IQR	Me	IQR	Me	IQR	Me	IQR
Hcy	10.17	8.30-13.10	10.14	7.92-13.30	10.16	8.67-13.23	10.26	8.46-12.62
TSH	1.86	1.41-2.48	2.08	1.57-2.84	1.79	1.36-2.39	1.92	1.37-2.59
T_3	4.10	3.79-4.62	4.52	3,94-4,80	4.14	3.80-4.60	3.99	3.68-4.46
T_4	1,18	1.07-1.28	1.21	1.12-1.28	1.18	1.09-1.29	1.13	1.03-1.28
T_3/T_4	3.51	3.12-4.05	3.67	3.25-4.37	3.51	3.12-4.06	3.50	3.03-3.95
PTH	35.00	28.20-43.58	41.60	32.85-49.85	35.0	25.1-42.70	31.45	28.45-43.20
CT	1.10	1.10-2.58	1.10	1.10-3.34	1.10	1.10-2.55	1.10	1.10-2.19
Cort	13.23	9.58-17.40	9.06	7.51-16.47	13.2	9.64-17.42	14.34	10.42-17.75
Tg	17.12	10.11-30.26	13.83	7.92-24.58	17.52	10.48-31.31	15.94	9.75-28.70
Ca	1.26	1.21-1.30	1.24	1.20-1.31	1.26	1.22-1.30	1.26	1.21-1.32
P	1.34	1.22-1.46	1.43	1.38-1.57	1.33	1.20-1.47	1.30	1.21-1.43
RI	12.45	11.46-13.71	10.20	9.49-10.50	12.02	11.53-12.94	14.59	14.20-15.18
^{137}Cs	1.65	1.53-10.85	1.75	1.50-6.09	1.70	1.57-12.30	1.53	1.41-1.70

COMPARATIVE ASSESSMENT OF THE CONTENT OF HOMOCYSTEINE, HORMONES AND MINERALS OFTHE BLOOD IN THE CHILDREN WITH DIFFERENT LEVELS OF PHYSICAL DEVELOPMENT LIVING NEAR CHORNOBYL EXCLUSION ZONE

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***Objective**: We compared thecontent of homocysteine, hormones and minerals of the blood in the children with different levels of physical development living in the settlements near Chornobyl exclusion zone.*
***Methods**: We used instrumental, laboratory, mathematical and statistical methods in the study.*
***Results**: 158 children (78 boys and 80 girls) from Polisskyi district, Kyiv oblast were examined within the projectsof the European Commission in Ukraine «Health and Ecological Programmes Connected with Chornobyl Exclusion Zone: Development, Training and Coordination of Health-Related Projects» and Rhфne-Alpes Regional Council (France). The studied territory has remained contaminated with radioactive substances after Chornobyl accident until the present day. [137]Cs incorporation was shown to affect negatively the physical development (PD) of the children. [137]Cs radionuclides cause the disorders of cellular energy, affect negatively thyroid hormone genesis. A significantly high level of free triiodothyronine (T_3), parathyroid hormone (PTH) and P was established in adolescents with abnormal low PD in comparison with the children with abnormal high PD. Correlations between the indices of PD, endocrine system and mineral metabolism, registered in a group of examined children, reflect the physiological response of the organism to the cell damage associated with an exposure to [137]Cs radionuclides. Comparison of the values of separate metabolic indices with the reference values does not always reflect objectively the severity of metabolic disorders.*
To identify the metabolic disorders under conditions of constant incorporation of [137]Cs radionuclides in a child's organism, it is necessary to use the information on the associations among several metabolic indices in a group of children living in the territory suffered from the accident at Chornobyl nuclear power plant.

Keywords: homocysteine, hormones, calcium, phosphorus, Rohrer's index, adolescents, radioactivelycontaminated territories.

ed that [137]Cs radionuclides has a negative effect on metabolic processes in cells of internal organs and skeletal muscles. At the same time, bone skeleton formation processes are not directly dependent on [137]Cs.

This radionuclide also has a negative effect on the synthesis of thyroid hormones, as evidenced by its strong inverse association with Tg in the group of children with an insufficient PG level.

Under these conditions, the need of peripheral tissues for thyroid hormones is provided by an increase in the release of T_4 from the iodine molecule with the help of the 5r' deiodinases [14], and in this regard, an increase in the formation of T_3. This is confirmed by a higher blood level of T_3 in the children with abnormal low PG compared with the children with an abnormal high PG level, as well as a direct association between a [137]Cs specific activity in a human body and the blood T_3 concentration.

Thyroid hormones, including T_3, have the ability to delay cell proliferation [15, 16], which can also be considered one of the reasons for a decrease in RI values.

The studies showed that T_3 is able to enhance the activity of PTH (table 6), and thereby affect the processes of bone tissue resorption.

Among the analysed metabolic variables, P had the largest number of associations (fig.).

The highest blood P level in children with normal low PG indicates that there is disturbed cellular metabolism associated with energy problems caused by the incorporation of [137]Cs into the body. This, in particular, is proved by a direct association between T_3 and P, and an inverse association between T_4 and P.

We found an inverse association between RI in the examined «Chornobyl» children and the activity of PTH, CT and blood P levels. However, at the same time, no association between RI and Ca and H_{cy} was observed.

It cannot be omitted that an increased blood P concentration was a stimulating factor for the hormonal metabolism of the thyroid and parathyroid glands. We consider this to be a reflection of the physiological response of a human body to cell damage associated with exposure to [137]Cs radionuclides.

The associations between P and PTH, P and T_3, P and TSH, reported in this study, have been previously established by us in previous studies in groups of children with no homozygous variant of the T risk allele of the MTHFR:677 polymorphism in the genome, which significantly reduces the activity of methylenetetrahydrofolate reductase, one of the the main enzymes of the folate cycle involved in the metabolism of H_{cy} [3].

It should be noted that the current study identified no associations between between Ca and PTH, Ca and P, at the same time, a direct association

was reported between Ca and H_{cy}.

The studies showed that comparison of separate metabolic variables with reference values is not informative for determining the health status of children living in the territory affected by the accident at the Chornobyl nuclear power plant. Under these conditions, information on associations between several metabolic variables will be of greater importance.

Conclusions

^{137}Cs incorporation into a body negatively affects the physical growth of children, as evidenced by the results of a correlation analysis, as well as the comparison of values of specific activity of this radionuclide in groups of children with different levels of physical growth.

^{137}Cs radionuclides disturb the cellular energy and also have a negative effect on thyroid hormone genesis.

The level of T_3, PTH and P is statistically significantly higher in the blood of children from the group of abnormal low physical growth than in that of children from the group of abnormal high physical growth.

Of all the analysed metabolites, P had the largest number of associations, while Ca had one direct association with H_{cy}.

Associations between variables of physical growth, endocrine system and mineral metabolism reported in a group of children living in the territory contaminated with radionuclides as a result of the Chornobyl nuclear power plant accident reflect the physiological response of a human body to cell damage associated with exposure to ^{137}Cs radionuclides.

Comparison of values of separate metabolic variables with reference values does not always objectively reflect the severity of metabolic disorders in children after the accident at the Chornobyl nuclear power plant.

To identify metabolic disorders under conditions of constant incorporation of ^{137}Cs radionuclides in a child's body,

Table 2

Statistically significant differences when comparing variables of metabolic processes in the blood of examined children from Groups of physical growth 1 and 2

Variables	Hcy	Tg	TSH	T_3	T_4	T_3/T_4	CT	PTH	Ca	P	Cort	RI	^{137}Cs
Average rank 1 (n = 17)	58.41	52.68	70.79	73.65	67.29	65.18	69.76	76.44	53.71	80.06	47.65	9.00	54.74
Average rank 2 (n = 103)	60.84	61.79	58.80	58.33	59.38	59.73	58.97	57.87	61.62	57.27	62.62	69.00	61.45
Mann-Whitney U test value	840.00	742.50	700.50	652.00	760.00	796.00	718.00	604.50	760.00	543.00	657.00	.00	777.50
Asymptotic significance (2-tailed)	.789	.317	.188	.093	.385	.550	.158	.041	.384	.012	.100	.000	.461

Table 3

Statistically significant differences when comparing variables of metabolic processes in the blood of examined children of Groups of physical growth 1 and 3

Variables	Hcy	Tg	TSH	T_3	T_4	T_3/T_4	CT	PTH	Ca	P	Cort	RI	^{137}Cs
Average rank 1 (n = 17)	27.47	25.94	30.15	35.56	31.38	30.82	31.62	34.97	24.68	37.85	21.82	9.00	35.00
Average rank 2 (n = 38)	28.24	28.92	27.04	24.62	26.49	26.74	26.38	24.88	29.49	23.59	30.76	36.50	24.87
Mann-Whitney U test value	314.00	288.00	286.50	194.50	265.50	275.00	261.50	204.50	266.50	155.50	218.00	.00	204.00
Asymptotic significance (2-tailed)	.870	.524	.506	.019	.295	.382	.187	.031	.302	.002	.056	.000	.030

Table 4

Statistically significant differences when comparing the indicators of metabolic processes in the blood of texamined children of Groups of physical growth 2 and 3

Variables	Hcy	Tg	TSH	T_3	T_4	T_3/T_4	CT	PTH	Ca	P	Cort	RI	^{137}Cs
Average rank 1 (n = 103)	70.82	71.87	69.30	73.82	73.08	72.19	71.50	71.42	70.45	72.84	69.89	52.00	79.70
Average rank 2 (n = 38)	71.50	68.63	75.61	63.37	65.36	72.19	69.66	69.86	72.49	66.00	74.00	122.50	47.42
Mann–Whitney U test value	1938.00	1867.0	1782.0	1667.0	1742.50	1834.00	906.00	1913.50	1900.50	1767.00	1843.00	.00	1061.00
Asymptotic significance (2-tailed)	.930	.676	.416	.178	.319	.568	.771	.840	.793	.377	.596	.000	.000

СРАВНИТЕЛЬНАЯ ОЦЕНКА СОДЕРЖАНИЯ В КРОВИ ГОМОЦИСТЕИНА, ГОРМОНОВ И МИНЕРАЛОВ У ДЕТЕЙ С РАЗЛИЧНЫМ УРОВНЕМ ФИЗИЧЕСКОГО РАЗВИТИЯ, ПРОЖИВАЮЩИХ ВБЛИЗИ ЧЕРНОБЫЛЬСКОЙ ЗОНЫ ОТЧУЖДЕНИЯ

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Цель: *сравнительная оценка содержания в крови гомоцистеина, гормонов и минералов у детей с различным уровнем физического развития, проживающих в населенных пунктах вблизи Чернобыльской зоны отчуждения.*
Методы исследования. *Инструментальный, лабораторный, математико-статистический.*
Результаты*. В рамках реализации в Украине проектов Европейской комиссии «Оздоровительные и экологические программы, связанные с Чернобыльской зоной отчуждения. Подготовка, обучение и координация проектов по охране здоровья» и Регионального Совета Рон-Альп (Франция) обследовано 158 детей (78 мальчиков и 80 девочек) из Полесского района Киевской области. Исследуемая территория до настоящего времени остается радиоактивно загрязненной после аварии на ЧАЭС. Показано, что инкорпорация ^{137}Cs в организм негативно влияет на физическое развитие (ФР) детей. Радионуклиды ^{137}Cs вызывают нарушение клеточной энергетики, негативно влияют на гормоногенез щитовидной железы. Установлен достоверно высокий уровень трийодтиронина свободного (T_3), паратиреоидного гормона (ПТГ) и Р у подростков с дисгармонично низким ФР по сравнению с детьми, имеющими дисгармонично высокое ФР. Корреляционные связи между показателями ФР, эндокринной системы и минерального обмена, регистрируемые в группе обследованных детей, отражают физиологический ответ организма на повреждение клеток, связанное с воздействием радионуклидов ^{137}Cs. Сопоставление значений отдельных метаболических показателей обмена веществ с референтными значениями не всегда объективно отражает тяжесть нарушений обмена веществ. Для определения нарушений обмена веществ в условиях постоянной инкорпорации радионуклидов ^{137}Cs в организме ребенка необходимо использовать информацию о связях между несколькими метаболическими показателями в группе детей, проживающих на территории, пострадавшей от аварии на Чернобыльской атомной электростанции.*
Ключевые слова: гомоцистеин, гормоны, кальций, фосфор, индекс Ропера, подростки, радиоактивно загрязненные территории.

it is necessary to use information on associations between several metabolic variables in a group of children living in the territory affected by the Chornobyl nuclear power plant accident.

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Table 5

Number of cases of differences in the analyzed variables with reference values in groups of children

Variables	Total group		Group 1		Group 2		Group 3	
	Abs.	%	Abs.	%	Abs.	%	Abs.	%
H_{cy}	84	53.16	9	52.94	55	53.40	20	52.63
TSH	4>RV	2.53	1>RV	5.88	1>RV	0.97	2>RV	5.26
T_3	18>RV, 1<RV	11.39; 0.63	3>RV	17.65	12>RV; 1<RV	11.65; 0.97	3>RV	7.90
T_4	49<RV	31.01	4<RV	23.53	29<RV	28.16	6<RV	42.11
PTH	6>RV	3.80	1>RV	5.88	4>RV	3.88	1>RV	2.63
CT	-	-	-	-	-	-	-	-
Cort	22>RV	13.92	2>RV	11.76	17>RV	16.50	3>RV	7.90
Tg	3>RV; 3<RV	1.90; 1.90	1<RV	5.88	2>RV; 2<RV	1.94; 1.94	1>RV	2.63
Ca	14>RV; 7<RV	8.86; 4.43	1>RV; 1<RV	5.88; 5.88	8>RV; 5<RV	7.77; 4.85	5>RV; 1<RV	13.16; 2.63
P	5>RV	3.17	1>RV	5.88	4>RV	3.88	0>RV	0

Note: RV – reference values. There are no significant statistical differences between groups.

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Fig.

Associations between Rohrer's index and blood metabolic variables in children from a total group

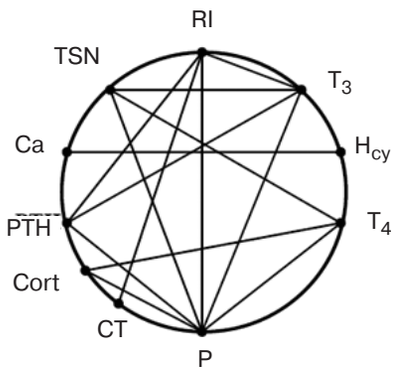

Table 6

Results of correlation analysis between RI, ^{137}Cs and metabolic variables in children from Polessky district

Parameters	Correlation coefficient	Value	Parameters	Correlation coefficient	Value
RI & ^{137}Cs	Spearman's	-.241**	^{137}Cs & T_3	Spearman's	.206**
	Sign. (2-tailed), p	.002		Sign. (2-tailed), p	.010
	N	158		N	158
RI & CT	Spearman's	-.175*	H_{cy} & Ca	Spearman's	.314**
	Sign. (2-tailed), p	.028		Sign. (2-tailed), p	.000
	N	158		N	158
RI & T_3	Spearman's	-.216**	TSH & T_4	Spearman's	-.239**
	Sign. (2-tailed), p	.006		Sign. (2-tailed), p	.002
	N	158		N	158
RI & P	Spearman's	-.250**	TSH & T_3	Spearman's	.211**
	Sign. (2-tailed), p	.002		Sign. (2-tailed), p	.008
	N	158		N	158
RI & PTH	Spearman's	-.165*	TSH & P	Spearman's	.178*
	Sign. (2-tailed), p	.038		Sign. (2-tailed), p	.026
	N	158		N	158
PTH & T_3	Spearman's	.243**	T_4 & P	Spearman's	-.196*
	Sign. (2-tailed), p	.002		Sign. (2-tailed), p	.014
	N	158		N	158
PTH & P	Spearman's	.301**	T_4 & Cort	Spearman's	.187*
	Sign. (2-tailed), p	.000		Sign. (2-tailed), p	.019
	N	158		N	158
T_3 & P	Spearman's	.290**	-	-	-
	Sign. (2-tailed), p	.000			
	N	158			

*Note: * – correlation is significant at the 0.05 level (2-tailed);*
*** – correlation is significant at the 0.01 level (2-tailed).*

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