прогностично несприятливою ознакою його перебігу. Синдром Рейно частіше виникає у пацієнтів з наявним ревматоїдним фактором у сироватці крові. У хворих на ревматоїдний артрит має місце недостатня ендотелій залежна вазорегуляція у плечовій артерії, що вказує на порушення ендотеліальної функції. У хворих на ревматоїдний артрит з вторинним синдромом Рейно спостерігаються більш виражені ознаки ендотеліальної дисфункції, що є свідченням високого ризику розвитку атеросклерозу та серцево-судинних ускладнень. Індекс відкритих капілярів дає можливість об'єктивно оцінити вираженість синдрому Рейно у хворих на ревматоїдний артрит.

Ключові слова: ревматоїдний артрит, синдром Рейно, ендотеліальна дисфункція.

Стаття надійшла 7.01.19 р.

прогностически неблагоприятным признаком его течения. Синдром Рейно чаще возникает у пациентов с имеющимся ревматоидным фактором в сыворотке крови. У больных ревматоидным артритом имеет место недостаточная эндотелий зависимая вазорегуляция в плечевой артерии, что указывает на нарушение эндотелиальной функции. У больных ревматоидным артритом с вторичным синдромом Рейно наблюдаются более выраженные признаки эндотелиальной дисфункции, что свидетельствует о высоком риске развития атеросклероза и сердечно-сосудистых осложнений. Индекс открытых капилляров дает возможность объективно оценить выраженность синдрома Рейно у больных ревматоидным артритом.

Ключевые слова: ревматоидный артрит, синдром Рейно, эндотелиальная дисфункция.

Рецензент Скрипник І.М.

DOI 10.26724/2079-8334-2020-1-71-149-153
UDC 616.1-02:612.392.64:37:613.11-053.4

O.M. Yurchyshyn, O.S. Komissarova[1], T.V. Fartushok [2], L.M. Palytsia, B.A. Lokai
I. Horbachevsky Ternopil National Medical University, Ternopil
[1]Shupyk National Medical Academy of Postgraduate Education, Kyiv
[2]Danylo Halytsky Lviv National Medical University, Lviv

CARDIOVASCULAR SYSTEM INDICATORS IN THE PRIMARY SCHOOL-AGED CHILDREN DURING THE ADAPTATION TO EDUCATIONAL LOADS IN THE REGION WITH IODINE EFICIENCY

e-mail: Oksana_urchushyn@ukr.net

The purpose of the study was to study the adaptive capacity of the cardiovascular system and to identify changes in the performance of heart rate variability in the primary school-aged children with iodine deficiency during the school year. It was found that among the 1st grade schoolchildren with iodine deficiency, 30% of children had the adaptive strategy tension at the beginning of the school year. The largest share of schoolchildren with low adaption level at the beginning of the school year was revealed. According to the indicators of heart rate variability, in 1-4 grades students with iodine deficiency the sympathetic nervous system influence is prevalent during the school year, while the parasympathetic nervous system is predominant in schoolchildren, properly provided with iodine.

Keywords: adaptation, heart rate variability, autonomic nervous system regulation, children, iodine deficiency.

The study is a fragment of the research project "Biochemical mechanisms of metabolic disorders in the presence of toxins of different origins", state registration No. 0116U003353.

The course of adaptation processes best reflects the functional state of the cardiovascular system (CVS), and the heart rate variability (HRV) allows to speak directly about the involvement of certain levels of the central nervous system (CNS) in the physiological functions regulation, in other words about the level of their centralization. According to the theory of R.M. Baevsky, the heart rate structure allows us to evaluate the state of the autonomic nervous system, the degree of organism adaptive resistance, the possibility of adaptive reserves [1, 5]. It is known that the higher the CNS level involved in the regulation of functional systems, the higher the adaptation tension [4, 9]. At the same time, it has been proved that thyroid hormones are essential for the maturation and functioning of the nervous system. Therefore, iodine deficiency (ID) may indirectly impair the adaptation course because of the negative effect on the nerve cell differentiation. One of the most scientifically based and informative methods of quantitative evaluation of the Autonomic Activity Indices, whose parameters are considered as integral indicators of regulation processes of the organism, is a method of computer cardiointervalography [3].

In this regard, to assess the iodine deficiency effect on the CVS activity, all children underwent cardiointervalography to determine the impact of individual autonomic nervous system sections.

The purpose of the study was to study the adaptive capacity of the child's organism to the school loads and to identify changes in the performance of cardiovascular system using heart rate variability in the primary school-aged children with iodine deficiency during the school year.

Materials and methods. The total of 243 schoolchildren from 1st to 4th grade were surveyed at the beginning, the middle and the end of the school year. In the first grade, 64 schoolchildren were healthy, 29 were with iodine deficiency, in the 2nd grade 34 children were healthy, and 18 were with iodine

deficiency, in 3rd grade 33 schoolchildren were with normal iodine content, and 25 were with iodine deficiency, in the 4th grade 17 schoolchildren were healthy and 23 were with iodine deficiency. Schoolchildren were divided into two groups based on iodine availability. The first group consisted of children with normal iodine content in the urine (control group), the second group – with iodine deficiency in the urine (experimental group).

The adaptive capacity level of the cardiovascular system was determined based on the Functional Status Index (FSI). The character of adaptation was determined by the FSI value [4]. When characterizing adaptation, we considered the child's behavior on the basis of the questionnaire of teachers using the test "Adaptation of children to school". (Kyrylenko M., 2006).

Heart rate variability was studied using the Neurosoft's Poly-Spectrum Computing Diagnostic Tool. In our study we took into account in horizontal – baseline test (b) – and in vertical position – orthostatic test (o) – the following indicators: average heart rate (HR), RR interval arithmetic mean value (M), standard deviation (SD), mode(Mo), amplitude of mode (AMo), RR interval median value (Me), deviation range (DR), vegetative equilibrium index (VEI), regulation adequacy index (RAI), vegetation rhythm index (VRI), tension index (TI), ratio of the tension index in the test to the index in the baseline test (TI_2/TI_1), increase in heart rate in the orthostatic test. The resulting digital material was processed by the Student's method of variational statistics, and also used the program STATISTICA 6.0., non-parametric methods (Mann-Whitney), P (u) = 0.05. Correlation analysis was performed using the program STATISTICA 10.0. To determine ioduria in children, the iodine excretion level in spot urine was examined with Dunn's test, and the thyroid was palpated.

Results of the study and their discussion. The most accurate indicator of the adaptive capacity of the organism, including the child's one, is the so-called "adaptive potential", which is quite often used in scientific studies. It defines the possibility of equilibrium between the child's organism and the environment by mobilizing the functional reserves of the CVS. Assessment of the adaptive potential (AP) changes makes it possible to diagnose prenosological conditions and control the effectiveness of rehabilitation measures [4, 9].

Emphasis should be placed on the leading role of determining the functional state of the circulatory system, both at resting state and during the physical activity in the studying of the health status of primary school-aged children. It should be noted that starting school is one of the critical periods in the life of the child, which is accompanied by a very high level of tension of the cardiovascular and sympathoadrenal systems, as well as a low indicator of the interaction of different systems with each other [10].

In the 1st grade, during a detailed ioduria analysis, 64 schoolchildren (69%) were found to be adequately provided with iodine and 27 schoolchildren (29%) were with mild ID, 1 schoolchild (1%) had moderate iodine deficiency and 1 schoolchild (1%) was with a severe ID.

In terms of urinary iodine excretion in the 2nd grade, 34 schoolchildren (65 %) were properly provided with iodine, 14 schoolchildren (27%) had a mild ID, and 4 schoolchildren (8%) had a moderate ID.

Among third-graders: 33 schoolchildren (57 %) were healthy relative to iodine provision and 25 schoolchildren (43 %) had iodine deficiency in their urine. In 4th grade 17 schoolchildren (42 %) were properly provided with iodine, and 23 schoolchildren (58%) had a mild ID.

Our AP indicators, as a criterion for quantifying health status, indicate that the satisfactory adaptation level in the children under observation is predominant. In particular, it was found that the highest percentage (93%) of first-graders with ID had a satisfactory adaptation level at the end of the school year, which exceeds the same indicator at the beginning and in the middle of the school year, and the highest percentage (30%) of the adaptive mechanisms tension is observed at the beginning of the school year. Such a pattern indicates a relatively higher adaptive capacity of the CVS in children provided with iodine. Changes in FSI (probable increase for almost 10% in children with ID) during the school year indicate comparatively lower adaptive capacity of CVS in schoolchildren with iodine deficiency relative to their peers.

Analyzing the questionnaire "Adaptation of children to school" at the beginning, middle and end of the school year, we have found that the largest share of schoolchildren with low adaptation level (13%) was detected at the beginning of the school year.

According to the results of heart rate variability, it was found that at the beginning of the school year the 1st grade schoolchildren with ID had lower values of VEI(b) by 37% ($p < 0.05$), TI(b) by 39% ($p < 0.05$) in relation to the similar data in healthy peers, which indicates the prevalence of the ANS parasympathetic effect in schoolchildren with iodine deficiency, which is consistent with the established data (Tsiapets G.B., 2010). In the middle of the school year, in children with ID was observed a lower value

of TI(b) by 36% (p <0.05) relative to the control, which indicates that the ANS parasympathetic effect was predominant in the schoolchildren of the experimental group. At the end of the school year, the DR(b) values were found to be lower by 48% (p <0.05) in schoolchildren with reference data, which indicates the dominance of sympathetic ANS in these schoolchildren.

At the beginning of the school year, in the 2nd grade schoolchildren with ID were found lower values of VEI(b) by 44% (p <0.05), TI(b) by 45% (p <0.05) relative to healthy peers, which indicates the prevalence of the impact of the ANS parasympathetic section in these children. In the middle of the school year, schoolchildren with ID had significantly higher DR(o) values (almost twice), which indicates the predominance of the parasympathetic nervous system. A 50% decrease in the TI_2/TI_1 indicator (p <0.05) indicates that there is a certain sympathetic tone in children with ID. However, on the basis of the quantitative correlation between the indicators obtained in the heart rate analysis in 2nd grade schoolchildren with ID in the middle of the school year, the parasympathetic nervous system prevails over the sympathetic one. At the end of the school year, lower values of Me(b) (by 60%, p <0.05), Me(o) (by 72%, p <0.05) and TI_2/TI_1 (by 68%, p <0.05) for similar indicators in the control group indicate a predominance of sympathetic tone in schoolchildren with ID.

In the 3rd grade at the beginning and in the middle of the school year, in schoolchildren with ID there were any significant differences between the studied data of heart rate variability. At the end of the school year there was a decrease in Mo(b).

At the same time, there were no significant differences between the indicators of heart rate variability in the 4-th grade schoolchildren with different iodine provision during the school year.

There was no correlation in the first-grade children between indicators of iodine deficiency, adaptive capacity and the child's age.

Table 1

Correlation between indicators of iodine deficiency, adaptive capacity and the child's age in the second grade schoolchildren

	Adaptive capacity in children	Iodine content in the urine	Age
Adaptive potential in children	-	r =0.0080 p=.955	r=0.1773 p=0.209
Iodine content in the urine	r = 0.0080 p=0.955	-	r = 0.2957 p=0.033
Age	r=0.1773 p=0.209	r = 0.2957 p=0.033	-

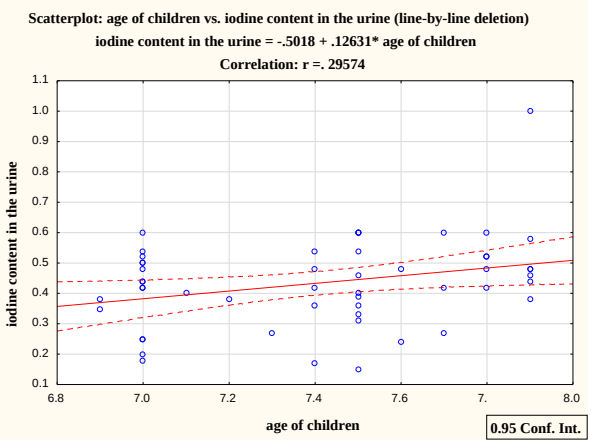

Fig. 1 Correlation between iodine values in the urine and child's age in the second grade schoolchildren

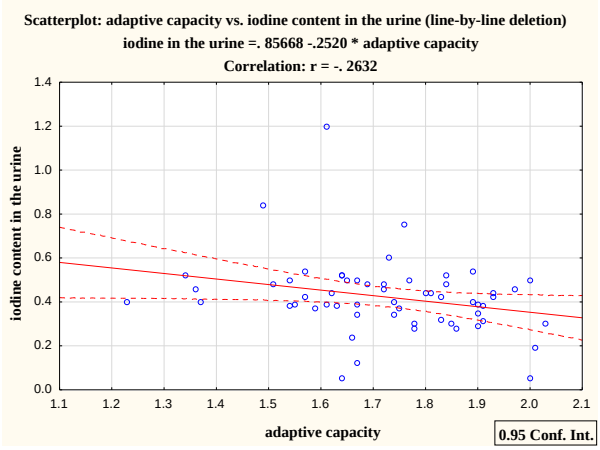

Fig. 2 Correlation between iodine values in the urine and adaptive potential in third grade schoolchildren

Thus, in the 2nd grade schoolchildren, there was a direct weak correlation between the iodine content in urine and the age (r = 0.2957, p = 0.033) (fig. 1).

Table 2

Correlation between indicators of iodine deficiency, adaptive capacity and the child's age in the third grade schoolchildren

	Adaptive potential in children	Iodine content in the urine	Age
Adaptive potential in children		r = 0.2632 p=.046	r = 0.2077 p=0.118
Iodine content in the urine	r = -0.2632 p=0.046	-	r = -.01272 p=0.341
Age	0.2077 p=0.118	r = -0.1272 p=0.341	-

Therefore, in the 3rd grade schoolchildren, there was an inverse weak correlation between the iodine content in urine and the adaptive potential (r = -0.2632, p = 0.046) (fig. 2).

Table 3

Correlation between indicators of iodine deficiency, adaptive capacity and the child's age in the fourth grade schoolchildren

	Adaptive potential in children	Iodine content in the urine	Age
Adaptive potential in children	-	r =-0.2537 p=.114	r =0.3135 p=0.049
Iodine content in the urine	r =-0.2537 p=0.114	-	r =-0,1131 p=0.487
Age	r =0.3135 p=0.049	r =-0,1131 p=0.487	-

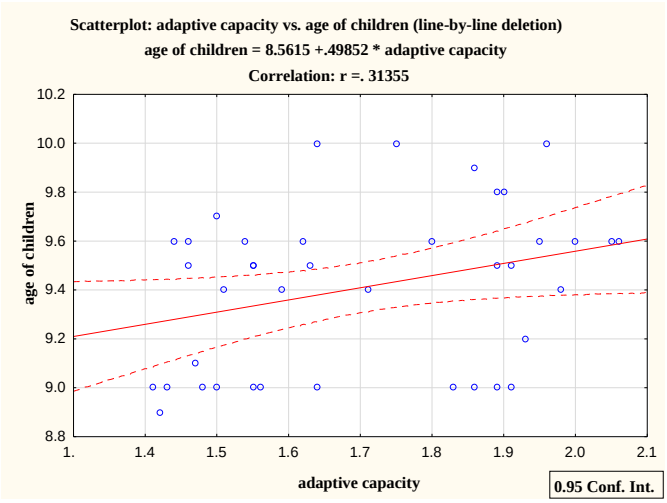

Fig. 3 Correlation between values of children's age and adaptive potential in the fourth grade schoolchildren

There was a direct weak correlation between age and adaptive potential in the fourth grade schoolchildren (r = 0.3135, p = 0.049) (fig.3).

Thus, the frequency of iodine deficiency among schoolchildren in the 1-4 grades is 39 % of children. The results of the study showed that among the 1st grade schoolchildren with ID, a third had the adaptive mechanism tensions at the beginning of the school year, compared with the middle and the end of the school year, and in relation to the similar indicators of the 2-4 grades schoolchildren, which is consistent with the data of other scientists [6, 4, 9]. This can be explained by the fact that starting school inevitably increases the brain load of the child, leads to a decrease in motor activity, changes the usual stereotype; it is an emotional-stress factor for many children and the maximum tension of neuro-psychological adaptive mechanisms. It is known that starting school is characterized by a failure of adaptation and a decrease in the reactivity of the child's organism [2]. It can be argued that younger schoolchildren do not adapt equally to educational loads. This is obviously due to their individual psychophysiological characteristics and environmental impact. According to the literature, reforming the education system has proved inadequate for the physiological capabilities of the child's organism. Thus, almost 30% of the first-graders have adaptation failures in the form of neurovegetative disorders, and an increase in the incidence rate [9].

The data obtained showed that the first-graders have an increase in sympathetic nervous system tone at the end of the school year in children with ID, compared to schoolchildren with normal iodine provision. The identified changes can be considered as a decrease in adaptation reserves of the organism, moderate depletion of regulatory influences, which is consistent with the established data of other authors [4, 9, 10, 11]. The Second- and the third-grade schoolchildren with ID by the end of the school year had an increase in the sympathetic nervous system tone [7, 8, 12]. Correlation analysis revealed that the higher the iodine content in the urine, the better the adaptive capacity in children.

Conclusion

The study results found that the highest levels of tension and the most children with low levels of adaptation were recorded in the first-graders at the beginning of the school year. Primary-aged schoolchildren with iodine deficiency had a higher percentage with the adaptive mechanisms tension, compared to schoolchildren who were properly provided with iodine.

According to the indicators of heart rate variability in the 1-4th grades schoolchildren with iodine deficiency during the school year, the sympathetic nervous system influence is prevalent (decrease of the deviation range index by 52 % ($p < 0.05$) and increase of the tension index by 2.3 times ($p < 0.05$), while in schoolchildren, adequately provided with iodine the parasympathetic nervous system is predominant (an increase of 2.4 times RR interval median value in the baseline test ($p < 0.05$) and 3.5 times in the orthostatic test ($p < 0.05$), ratio of the tension index in the test to the index in the baseline test by 2.3 times ($p < 0.05$).

Prospects of further research lie in assessment of the functional state of the cardiovascular system allows to assess the adaptation state of the child's organism and to predict the possibility of pathology, including the thyroid gland, at the prenosological stage. Children, diagnosed with iodine deficiency using a screening test, need in-depth clinical and laboratory-instrumental examination not only of the thyroid gland but also of other organs.

References

1. Babii IL, Velychko VI, Venher YI. Adaptatsiyni mozhlyvosti shkoliariv. Zdorovye Rebenka. 2011; 8(35):20–24. [in Russian]
2. Basanets LM, Ivanova OI. Vplyv mikrosotsialnoho seredovyshcha na fizychnyi rozvytok i stan zdorovya ditey ta pidlitkiv. Dovkillia i Zdorovya. 2010; 1:52–55. [in Ukrainian]
3. Berezhnyi VV, Romankevych IV. Zastosuvannia vyznachennia variabelnosti sertsevoho rytmu u ditey. Sovremennaya pediatriya. 2015; 1(65): 87–90. [in Russian]
4. Hlazkov YO. Pokaznyky tsentralnoyi hemodynamiky pry porushenni adaptatsii studentiv molodshykh kursiv do navchalnoyi diyalnosti. Ukrayinskyi zhurnal ekstremalnoyi medytsyny imeni H.O. Mozhayeva. 2012; 13(3): 18–21. [in Ukrainian].
5. Kostromina VP, Rechkina OO, Yaroshchuk LB. Adaptatsiyno-rezervni mozhlyvosti orhanizmu ditey khvorykh na bronkhialnu astmu. Astma ta alerhiya. 2014; 3:13–19. [in Ukrainian].
6. Makhlovanyi AV, Plastunov BA, Kovaliv MO. Otsinka funktsionalnykh rezerviv sertsevo-sudynnoyi systemy studentiv-pershokursnykiv zalezhno vid vmistu yodu ta svyntsiu v orhanizmi. Lvivskyi medychnyi chasopys. 2012; 18(2): 91–95. [in Ukrainian].
7.Mamenko MY. Yodnyi defitsyt ta yododefitsytni zakhvoriuvannia. Perinatolohiya i pediatriya. 2013; 1(53):97-105 [in Ukrainian]
8.Ryabukha OI. Deyaki aspekty vplyvu shchytopodibnoi zalozy na stan orhanizmu v umovakh normy i patolohiyi. Aktualni problemy suchasnoyi medytsyny. Visnyk Ukrayinskoyi medychnoyi stomatolohichnoyi akademiyi. 2018; 18(3):324–330. [in Ukrainian]
9.Stroy OA, Slipachuk LV, Kazakova LM, ReznikovYuP. Otsinka adaptatsiinykh mozhlyvostey shkoliariv mista Kyiva z yododefitsytom. Zdobutky klinichnoyi i eksperymentalnoyi medytsyny. 2016; 3:92–95. [in Ukrainian]
10.Tsiapets GB. Rol avtonomnoyi nervovoyi systemy u adaptatsiyi do navchalnoho protsesu odno- ta dvomovnykh ditey molodshoho shkilnoho viku [dysertatsiya]. Lviv: Lvivskyi natsionalnyi universytet imeni Ivana Franka; 2011. 19s. [in Ukrainian]
11.Voronych SM, Pavlykivska BM, Voronych-Semchenko NM. Physiological Aspects of Analysis of Heart Rate Variability Parameters in Adolescents with Latent Hypothyroidism. International Journal of Physiology and Pathophysiology. 2012; 3 (1): 153–388.
12.Ryabukha O.I. Application of mathematical approaches in medicine on the example of follicular thyrocytes secretory activity study. World of Medicine and Biology. 2019; 1(67):181–187.

Реферати

ПОКАЗНИКИ СЕРЦЕВО-СУДИННОЇ СИСТЕМИ ПІД ЧАС АДАПТАЦІЇ ДО НАВЧАЛЬНИХ НАВАНТАЖЕНЬ ОРГАНІЗМУ ДІТЕЙ МОЛОДШОГО ШКІЛЬНОГО ВІКУ В ЙОДОДЕФІЦИТНОМУ РЕГІОНІ

Юрчишин О.М., Комісарова О.С., Фартушок Т.В., Палиця Л.М., Локай Б.А.

Метою дослідження було вивчення адаптаційних можливостей серцево-судинної системи та виявлення змін в показниках роботи варіабельності серцевого ритму в дітей молодшого шкільного віку з йододефіцитом впродовж навчального року. Встановлено, що серед дітей 1-их класів із дефіцитом йоду 30% дітей мали на початку навчального року напруження механізмів адаптації. Виявлено найбільшу частку школярів із низьким рівнем адаптації на початку навчального року. Згідно показників варіабельності серцевого ритму, у дітей 1-4-их класів з дефіцитом йоду впродовж навчального року домінує вплив симпатичної нервової системи, тоді як у школярів, належним чином забезпечених йодом, переважає парасимпатична нервова система

Ключові слова: адаптація, варіабельність серцевого ритму, автономна нервова регуляція, діти, йододефіцит.

Стаття надійшла 26.04.2019 р.

ИССЛЕДОВАНИЕ ИЗМЕНЕНИЙ В ПОКАЗАТЕЛЯХ СЕРДЕЧНО-СОСУДИСТОЙ СИСТЕМЫ ПРИ АДАПТАЦИИ К УЧЕБНЫМ НАГРУЗКАМ ОРГАНИЗМА ДЕТЕЙ МЛАДШЕГО ШКОЛЬНОГО ВОЗРАСТА В ЙОДОДЕФИЦИТНОМ РЕГИОНЕ

Юрчишин О.М., Комиссарова О.С., Фартушок Т.В., Палица Л.М., Локай Б.А.

Целью исследования было изучение адаптационных возможностей сердечно-сосудистой системы и выявления изменений в показателях работы вариабельности сердечного ритма у детей младшего школьного возраста с йододефицитом в течение учебного года. Установлено, что среди детей первого классов с дефицитом йода 30% имели в начале учебного года напряжение механизмов адаптации. Выявлено наибольшую часть школьников с низким уровнем адаптации в начале учебного года. Согласно показателям вариабельности сердечного ритма у детей 1-4-х классов с дефицитом йода в течение учебного года доминирует влияние симпатической нервной системы, тогда как у школьников с обеспеченных йодом преобладает парасимпатическая нервная система

Ключевые слова: адаптация, вариабельность сердечного ритма, автономная нервная регуляция, дети, йододефицит.

Рецензент Крючко Т.О.