Autonomic Dysfunction in Preschool Children with Neurotic Disorders

Zaryana Olexyuk*, Aiman Konkabayeva, Gulnaziya Alshynbekova, Gulmira Tykezhanova, Sholpan Nugumanova and Manara Mukasheva

E.A. Buketov Karaganda State University, Karaganda, Kazakhstan

Abstract: In the last decades of the 21st century, the problem of a significant increase in the number of children with disorders in mental and somatic development has become particularly acute. Often there are neurotic conditions caused by the influence of various psycho-traumatic factors: the growth of scientific and technological progress and related changes in all areas of human life activity. In this regard, shifts occurred in the structure of the incidence among the population towards an increase in the proportion of diseases associated with nervous and psychic overstrain. One of the most vulnerable age groups is children of preschool and primary school age. Untimely diagnosed neurotic disorders in children, as a rule, turn into protracted forms of neurotic conditions and subsequently become chronic. This, of course, affects the adaptation of the individual in society and the further quality of life.

This study, aimed at assessing autonomic regulation in preschool children with different psychological status, allowed to reveal the activity of the sympathetic and parasympathetic link of the autonomic nervous system (ANS) by the method of cardiointervalography according to R.M. Baevskii. We examined 127 children aged 4-5.5 years old. The average statistical indicators characterizing the regulation of heart rate (HR, HF, LF, VLF, LF/HF, TP, SI) in preschool children in various groups (neurosis, pre-neurosis, anxiety, and normal) were determined. The study revealed changes in the regulation of heart rhythm in children with neurotic disorders, which indicates an increase in the influence of the sympathetic circuit of autonomic regulation and a decrease in parasympathetic influences. Overstrain of vegetative centres in children with neurosis and pre-neurotic conditions is determined by high psychoemotional stresses.

Keywords: Preschool children, neurosis, pre-neurosis, anxiety, heart rate variability, sympathetic and parasympathetic nervous system.

INTRODUCTION

Preschool children remain the most vulnerable group, as they experience increased academic and nervous loads (besides kindergarten, children often attend various early childhood development schools, sports sections and clubs), which leads to a lack of free time and leisure time. This, in turn, leads to an increase of psycho-emotional stress, and subsequently to neurotic disorders in children. The official statistics confirm the above: in the Republic of Kazakhstan, the incidence among children is 94.9 cases per 100 children [1]. Besides, there is an increase in mental and behavioural disorders (601 cases per 100,000 children) [2]. Thus, in Kazakhstan, every sixth child under 14 has pathology from the psyche and nervous system, which includes neurotic disorders. Indeed, this does not reflect the true picture of the prevalence of neurotic disorders, since the appeal to statistical data in foreign [3], Russian [4], Kazakhstani [5] sources indicate only registered cases. The prevalence of borderline conditions is much greater, taking into account that often such children do not fall into the field of vision of neuropsychiatric services, due to the low number of parents' appeals who consider such children to be healthy. Neurotic disorders are understood as a group of functional disorders of higher nervous activity caused by psycho-traumatic impact, manifested in emotional and somatic-vegetative disorders, called "neurosis" [4, p. 8].

Studies of childhood neuroses are currently described quite rarely and are mostly psychological in nature. Along with this, violation of the functional state in neurotic disorders transform the activity of various organs and systems, as a result of which disturbances in the cardiovascular, respiratory, digestive and other systems occur. Cardiac activity differs from others with high reactivity and affects adaptive changes in the functional state of the body. This determines its almost immediate involvement in the stressful reactions of the body [6]. Besides, the activity of the cardiovascular system is the most informative indicator of changes in the state of the child's body, as with painful changes, there is an imbalance in its work.

In the scientific literature, there is no detailed analysis of the state of the cardiovascular system in preschool children with neurotic disorders. Meanwhile, the determination of heart rate variability (HRV) is recognized as the most informative non-invasive method for quantifying the autonomic regulation of heart rate. HRV indicators reflect the vital parameters of controlling the physiological functions of the body -

*Address correspondence to this author at the E.A. Buketov Karaganda State University, Karaganda, Kazakhstan; Tel: +7721277-01-76;
Fax: +8721235-63-98; E-mail: oleksyuk_z@mail.ru

E-ISSN: 2292-2598/20

the vegetative balance and functional reserves of its control mechanisms [7]. By analyzing HRV, we can not only evaluate the functional state of the body but also monitor its dynamics, up to pathological conditions.

MATERIALS AND METHODS

Subjects

The research was conducted in the children preschool establishments – a nursery No 15 "Akku", a kindergarten "Tolagay" (Kazakhstan, Karaganda) and was comprehensive: psychological and physiological changes in preschool children with neurotic disorders were taken into account. The information, received from the kindergarten educators and their parents, was supplemented by data from medical records. All examined children were catamnestically followed up from 1 year to 4 years.

In total, 127 children participated in the study. The studied contingent was divided into two groups: children with a diagnosis of "neurotic disorder" and a group of healthy children.

Based on psycho-tests [8], two independent groups were identified from the group of "healthy" preschool children: "pre-neurosis" – children of this group are similar in their psychological state to the group "neurosis", but they did not have a medical report from specialists; and the group "anxiety" which includes preschool children with a high level of anxiety.

Children were divided into four groups: 22 children with an established diagnosis of the neurotic disorder, 18 children with the pre-neurotic state, 40 children with a high level of anxiety, 47 children with normal development.

The age of children ranged from 4 to 5 years and 5 months old. The criteria for inclusion in the groups were the following:

1. Preschool age (4-5.5 years);
2. Inorganic aetiology;
3. The presence of psychogenic disease that meets the criteria of the ICD-10 rubric F90-F98 "Behavioural and emotional disorders with onset usually occurring in childhood and adolescence".
4. Short-term reactions in children lasting less than 1 week, including acute reactions to stress.
5. The voluntary consent of children and their parents to the research.

The research excluded the following children:

1. With the presence of any organic pathology.
2. Refusal of parents or children to participate in the research.

Research Methods

The physical development indicators of children were within the age norm. The average body weight of children aged 4 to 5 years old was 15.2 ± 1.3 kg; from 5 to 5.5 years old – 21.4 ± 1.1 kg. The average height of children aged 4 to 5 years old was 103 ± 0.9 cm; from 5 to 5.5 years old – 108.4 ± 2.1 cm.

The pressure was measured on both hands with a CS-106 tonometer using a children's cuff. For a reliable result, the pressure was measured 3 times with an interval of 5 minutes. The average of three measurements was used to estimate arterial pressure.

The study of heart rate variability in preschool children was conducted using the cardiointervalography method according to R.M. Baevskii with the complex "Varicard" [9] and the software "ISCIM-6". In many cases, indicators of heart rate variability allow to determine changes in the body earlier, than the results of clinical, laboratory, radiological, electrocardiographic, and other data.

The following HRV indicators were studied in the research: heart rate (HR), HF – high-frequency parasympathetic components, LF – low-frequency components of the vasomotor centre, VLF – very-low-frequency sympathetic components, the ratio of the sympathetic and parasympathetic divisions of the ANS (LF/HF), TP – a sum of capacities in the ranges HF, LF and VLF, index of activity of regulatory systems (IARS), index of the tension of regulatory systems – stress index (SI).

The examination was conducted in the morning from 9 to 12 in a quiet room. For the registration of cardiac rhythms, electrodes were placed on the child's hands in the area of the lower third of the forearm (wrist) and lower part of legs. Heart rate variability parameters were recorded in the second lead placement.

Statistical Analysis

Fisher's analysis of variance or F-test was used to solve the problem of detecting differences in these parameters.

RESULTS

Statistically significant differences in this part of the study were found not in all parameters. No significant differences were found in parameters like "Age", "Growth", "Weight", SD, CV, IC, the relative level of activity of the parasympathetic regulation link - HF, the relative level of activity of the sympathetic regulation link – LF and VLF, their ratio to each other LF/HF, the rate of activity levels of the central and autonomic regulation circuits – TP, in blood pressure indicators on both hands (upper and lower). This means that children with varying degrees of neurotization do not statistically differ (according to our results) in terms of the above indicators.

In the body of a healthy child, the influence of the parasympathetic and sympathetic divisions are in a state of optimal balance. There is a possible slight predominance of one of them, due to the immaturity of one of the divisions, or uneven maturation, which is also a variant of the norm. In our case, the absence of significant differences in the values of LF/HF F = 0.329 at p = 0.805 is noteworthy.

It is known that if the ratio LF/HF is less than 1, the parasympathetic part of the CNS predominates; if the ratio LF/HF is more than 1, the sympathetic division dominates [11]. However, there is a sufficiently wide range within which it is unacceptable to talk about the predominance of a particular division of the ANS. The range of "normal" LF/HF ratios depends on age, living conditions, adaptation to the environment, and daily level of physical activity. In our case, it is appropriate to interpret the obtained data as an imperfection of regulatory mechanisms – "incomplete adaptation", more precisely, the "search stage of adaptation" in preschool children [12].

Significant differences among preschool children were found in indicators of heart rate, IARS, stress index and are presented in Table **1**.

An increase in sympathetic regulation in the group "Neurosis" is indicated by heart rate, which demonstrates statistically significant differences, where F = 4.87 at p = 0.003. Taking into account the parameters of the arithmetic mean for heart rate, it can be seen that the differences are determined by a significant excess in the group "Neurosis" (100.840 ± 2.740), reaching the upper boundary of the reference values. At the same time, between the groups "Pre-neurosis" (92.200 ± 2.171), "Anxiety" (94.571 ± 1.386) and "Normal" (91.885 ± 1.216), there were no significant differences in this parameter, but the groups did not correspond to normal values (Figure **1**).

The study of the correlational relationship of the heart rate variability with psychological indicators showed the following. There was revealed a reliable relationship between heart rate and medical fears (r = 0.173; p≤0.05); animals and fairy-tale characters (r = 0.168; p≤0.05); nightmares and fears of the darkness (r = 0.232; p≤0.05). This orientation of the relationship shows that the more explicit the above-described fears are, the higher the heart rate is.

Indicators for the parameter SI (index of the tension of regulatory systems) also demonstrated statistical significance at F = 6.04 and p = 0.001. The indicators of the first three groups: "Normal" 138.942 ± 17.6

Table 1: Heart Rate Variability Indicators in Children of Different Groups (Parameters with Significant Differences are Presented)

Scale	Statistical parameter	Groups				
		Neurosis	Pre-neurosis	Anxiety	Normal	Whole sample
Heart rate, bpm	M	100.840	92.200	94.571	91.885	94.353
Heart rate, bpm	SD	13.701	9.709	8.980	8.766	10.421
Heart rate, bpm	Std.Err.	2.740	2.171	1.386	1.216	0.884
IARS	M	5.880	5.500	5.429	4.615	5.216
IARS	SD	1.236	1.235	1.346	1.360	1.392
IARS	Std.Err.	0.247	0.276	0.208	0.189	0.118
SI (stress index)	M	332.080	139.450	149.405	138.942	176.914
SI (stress index)	SD	42.024	15.328	11.764	17.516	22.286
SI (stress index)	Std.Err.	8.405	2.788	1.400	17.683	8.006

Notes: M – mean; SD – standard deviation; Std.Err. – standard error.

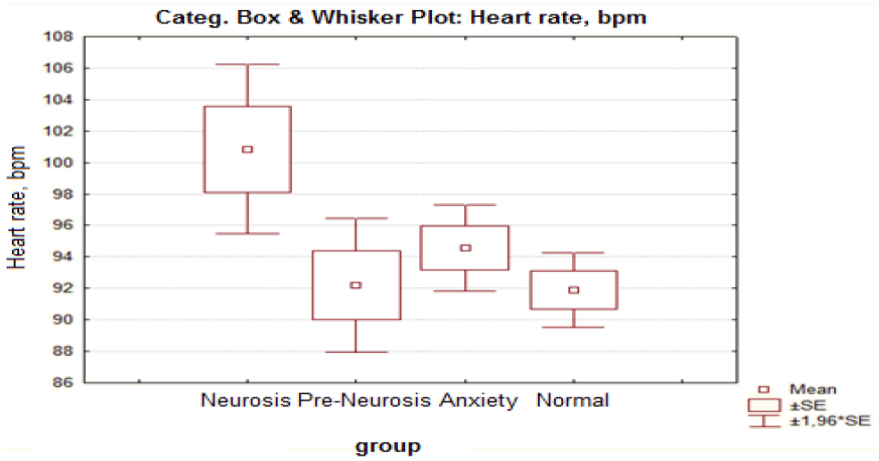

Figure 1: Comparative dynamics in heart rate parameter in preschool children.

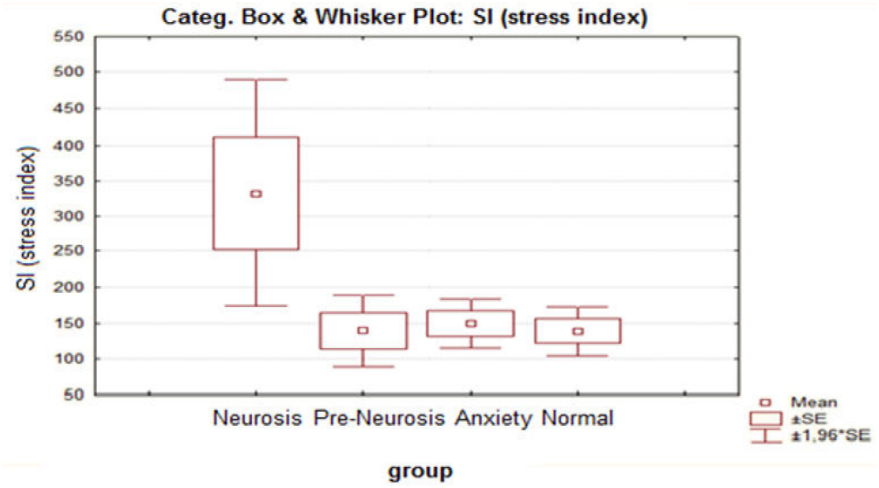

Figure 2: Comparative dynamics in "SI" parameter.

conventional units, "Anxiety" 149.405 ± 1.4 conventional units, and "Pre-neurosis" 139.450 ± 2.7 conventional units, did not show a significant difference. In the group "Neurosis" SI made up 332,080 ± 8,405 conventional units, there is a tendency of this indicator to increase (Figure **2**).

Noteworthy is the wide variation in SI values in the group of children with neurosis. SI depends on the tone of the sympathetic nervous system and the state of the central regulation circuit. High values of this indicator in the children in the group "Neurosis" allow to classify them as super sympathicotonic type, and reflect the tension of regulatory systems and also indicate a decrease in the reserve capacity of the body.

The obtained data serve as the basis for the assumption of overstrain of autonomic centres in children in the group "Neurosis", due to high psycho-emotional loads. This is confirmed by the discovered correlations of SI with medical ($r = 0.205$; $p \leq 0.05$) and physical ($r = 0.169$; $p \leq 0.05$) fears.

The parameters of the criterion IARS (index of activity of regulatory systems) showed the next significant difference. The value of the F-criterion was 6.39 at $p = 0.001$. The indicators of activity of regulatory systems increase quite smoothly from the group "Normal" (4.615 ± 0.189), which indicates the state of moderate tension of regulatory systems; "Anxiety" (5.429 ± 0.208) and "Pre-neurosis" (5.500 ± 0.276) are characterized by explicit tension of regulatory systems, due to the active mobilization of protective mechanisms, including increased activity of the sympathetic-adrenal system (Figure **3**).

Values of IARS in the groups are characterized by slight differences, but the variation of values in the group "Pre-neurosis" indicates the worse condition of this group of children.

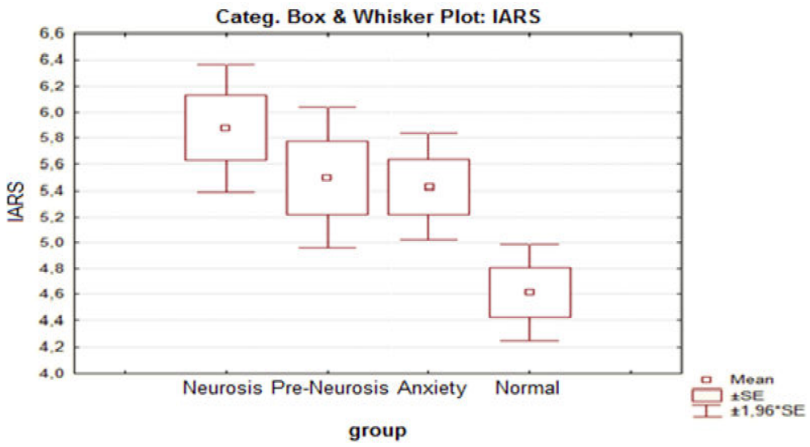

Figure 3: Comparative dynamics in "IARS" parameter.

In the group of children with neurosis, IARS reaches maximum results of 5.880 ± 0.247, which indicates a state close to overstrain of regulatory systems. Besides, the association of IARS with medical fear (r = 0.196; p≤0.05) was found in this group of children.

DISCUSSION

It is well known that a shift in autonomic tone towards sympathicotonia is a characteristic of the state of stress, as was pointed out by many scientists at different times. Particularly, Levi L. noted restructuring of the cardiovascular system's functioning, manifested in the activation of the sympathetic nervous system in combination with an increase in glucocorticoids, as a result of the emotional stress [13].

In children in the group "Neurosis", SI exceeded normal values ten times, which is a sign of decompensated distress, expressed in the tension of adaptive systems, changes in metabolism [14], endocrine background [15], the functioning of the immune system [16], and behaviour.

The possibility of forming such a condition is caused by hypersympathicotonia's contribution to the launch of several regulatory disorders that affect the development of a child. In addition, activation of the sympathetic nervous system leads to an increased release of catecholamines (noradrenaline, adrenaline and decreased dopamine) [17], and promotes the excretion of magnesium from cells. This leads to the depletion of intracellular magnesium, which entails an increase in magnesium in primary urine and its loss with urine [18]. Somatic magnesium deficiency in children is manifested in paresthesia of the palms of the hands and feet, in convulsions of the muscles of the legs and arms, tremors, sleep disturbances and diminished stress resistance [19, 20]. Magnesium deficiency also affects cognitive processes, manifested in decreased attention and memory.

The above is confirmed by the objective data, derived from the analvsis of children's medical records: increased excitability ─ in 72%; nocturnal enuresis ─ in 18%; nocturnal and diurnal enuresis ─ in 4.5%; sleep disturbances ─ in 54.5%; compulsive actions ─ in 45.4%; tics ─ in 9% of children in the group "Neurosis".

A long-running stressful situation leads to dysfunctions of the hypothalamus, hypophysis and adrenal glands, as a result of which the functional resources of the neuroendocrine system are involved in the pathological link [21], this creates conditions under which the general adaptation syndrome does not form, and stress can reach the "stage of exhaustion".

Thus, the active reaction of the neural link of the sympathetic-adrenal system, which is a necessary element of the physiological reaction of protective and adaptive mechanisms, in preschool children with neurotic disorders, fulfils not only the sanogenetic, but also the pathogenetic role and, therefore, can be considered as an important factor in the pathogenesis of neurosis in preschool children [22].

CONCLUSIONS

The cardiovascular system, as a component of multiparameter interaction, responds to any changes in homeostasis, and its physiological parameters can objectively reflect the state of the body.

The results of HRV analysis using the complex "Varicard" indicate the predominance of activity of the sympathetic nervous system in children in the groups "Neurosis" and "Pre-neurosis". HR (heart rate), SI (index of the tension of regulatory systems), IARS

(index of activity of regulatory systems) are significantly increased. Overstrain of autonomic centres in children in the groups "Neurosis", "Pre-neurosis" is determined by high psycho-emotional stress.

The index of the tension of regulatory systems in children in the group "Neurosis" is an indicator of the primary stress-syndrome, which reduces the protective and adaptive capabilities of the body and the ability to withstand adverse environmental factors. The duration and intensity of psycho-emotional stress, the activation of sympathetic regulation in the future, in this group of children, can lead to clinical manifestation in the form of a chronic course of neurosis.

ACKNOWLEDGEMENTS

The study was conducted in children preschool establishments – a nursery No 15 “Akku”, a kindergarten “Tolagay” in the city of Karaganda, the Republic of Kazakhstan. The authors are deeply grateful to the head of “Tolagay” kindergarten, Usenova Gulnara, and the head of “Akku” kindergarten, Bazarbaeva Alua, for their help and support in conducting the scientific research.

REFERENCES

[1] Doklad o polozhenii detej v Respublike Kazahstan [Report on the situation of children in the Republic of Kazakhstan]. Astana 2017; p. 41.

[2] 2017 zhylda Kazakstan Respublikasy halkynyn densaulygy zhəne densaulyk saktau ujymdarynyn kyzmeti [Health and health care organizations in the Republic of Kazakhstan in 2017]. Statistikalyk zhinak [Statistical summary]. Astana 2018; p. 354.

[3] Farmer C, Farrand P, O’Mahen H. I am not a depressed per-son: how identity conflict affects help-seeking rates for major depressive disorder. BMC Psychiatry 2012; №12: 164-174. https://doi.org/10.1186/1471-244X-12-164

[4] Devyatova OE. Pogranichnye psihicheskie rasstrojstva u detej v situaciyah semejnoj deprivacii: avtoref. kand. med. nauk: 14.00.18. [Borderline mental disorders at children in situations of family deprivation: synopsys of diss. for candidate of medical sciences: 14.00.18.]. M.: GNCSiSP im. V.P.Serbskogo Federal' nogo agentstva po zdravoohraneniyu i social 'nomu razvitiyu RF [M.; The Serbsky State Scientific Center for Social and Forensic Psychiatry], 2005. Inv. № 04200517383.

[5] Katkov AL, Dzharbusynova BB. Rasstrojstva, svyazannye so stressom, i somatoformnye rasstrojstva po materialam epidemiologicheskogo issledovaniya 2003 goda [Survey on stress and somatoform disorders based on epidemiological study in 2003]. Pavlodar 2006; p. 327.

[6] Simonenko VB, Shirokov EA. Basic concepts of cardioneurology: the therapist’s guideline. Moscow: Medicine 2001; pp. 3-240.

[7] Baevskii RM. Heart rate variability analysis: history and philosophy, theory and practice. J Clin Comp Sci Telemed 2004; 1: 54-64.

[8] Konkabayeva AYe, Dakhbay BD, Oleksyuk ZYa, Tykezhanova GM, Alshynbecova GK, Staricova AYe. Research of fears of preschool age children. International Journal of Environmental and Science Education 2016; 15(11): 8517-8535.

[9] Baevskii RM, Semenov YN. Complex for cardiointervalogramms processing and analysis of heart rate variability. Varicard 2.51. Ryazan: Ramena 2007; pp. 3-288.

[10] Rukovodstvo po kardiologii: v 2 ch. [Cardiology Guide: in 2 volumes], pod.red. V.N. Kovalenko [ed. Kovalenko V.N.]. K.: Morion Publishing House 2008; 2: 1424.

[11] Oleksyuk ZYa. Osobennosti variabel' nosti serdechnogo ritma u doshkol 'nikov s nevroticheskimi proyavleniyami [Features of heart rate variability at preschool children with neurotic manifestations] // Collection of articles of XIV international scien.-pract. conf. «Strategiczne pytania swiatowej nauki – 2018». Przemysl 2018; 5: 35-38.

[12] Malliani A. Physiological Interpretation of Spectral Components of Heart Rate Variability. In: Malik M. (eds.) Clinical Guide to Cardiac Autonomic Tests. Dordrecht: Springer 1998; pp. 47-56. https://doi.org/10.1007/978-94-017-1057-2_7

[13] Levi L. Stress and distress in response to psychosocial stimuli. Acta Med Scand 1972; 528(191); 3-166.

[14] Karvasarskij BD. Nevrozy [Neuroses]. M.: Medicine 1990; p. 576.

[15] Murakami H, Ohira H. Influence of attention manipulation on emotion and autonomic responses. Percept. and mot. Skills 2007; 1(105): 1133-1140. https://doi.org/10.2466/pms.105.1.299-308

[16] Kryzhanovskij GN, Akmaev IG, Magaeva SV, Morozov SG. Nejroimmunoendokrinnye vzaimodejstviya v norme i patologii [Neuroimmunoendocrine interactions in norm and pathology]. M.: Medicinskaya kniga [Medical book]; 2010; p. 288.

[17] Oleksyuk ZYa, Dakhbay BD, Danilenko M. The role of catecholamines in preschool children in the neurotic development pathogenesis. Bulletin of the University of Karaganda. Series «Biology. Medicine. Geography» 2018; 2(86): 95-101.

[18] Gromova OA, Egorova EYu, Torshin IYu, Fedotova LE, Yudina NV. Perspektivy primeneniya magniya v pediatrii i detskoj nevrologii [Prospects for the use of magnesium in pediatrics and pediatric neurology]. Media 2012; 1(4): 91-96.

[19] Gromova OA, Nikonov AA. Rol’ i znachenie magniya v patogeneze zabolevanij nervnoj sistemy [The role and importance of magnesium in the pathogenesis of diseases of the nervous system]. Zh. nevrol. i psihiatr. im. S.S. Korsakova [S.S. Korsakov Journal of Neurology and Psychiatry] 2002; 12: 45-49.

[20] Eby G, Eby K. Magnesium for treatment-resistant depression: a review and hypothesis. Med Hypotheses 2010; 4(74): 649-660. https://doi.org/10.1016/j.mehy.2009.10.051

[21] Fesenko YuA. Pogranichnye nervno-psihicheskie rasstrojstva u detej [Borderline neuropsychiatric disorders in children]. SPb.: Nauka i tekhnika [Science and technology] 2010: p. 320.

[22] Martynova SE. “Service” municipal administration: The main components of model and its development in Russia”, Review of European Studies 2014; 6(4): 223-231. https://doi.org/10.5539/res.v6n4p223

Received on 30-01-2020 Accepted on 20-03-2020 Published on 15-05-2020

DOI: https://doi.org/10.6000/2292-2598.2020.08.02.8