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Developmental Features of the Formation of the Brain's Bioelectrical Activity in Children with Remote Consequences of a Perinatal Lesion of the CNS: II. EEG Typology in Health and Mental Disorders

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Abstract—The results of studies on the developmental EEG dynamics in children with long-term effects of perinatal CNS pathology are presented. The most common EEG types have been identified, and the differences in their distribution in normal and abnormal mental development were shown. On the basis of the results of a longitudinal study, early markers of the risk of ontogenetic deviations have been described that allow the consequences of perinatal CNS lesion to be minimized and abnormal variants of the formation of higher mental functions to be prevented.

Keywords: perinatal CNS pathology, EEG, abnormalities of mental developmental in children.

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In order to assess the degree of maturity of a child's age-related biorhythm structure, the α-rhythm formation values are used in many neurophysiological studies [1–4]. In our communication I [5], it was shown that the maturity markers for neurologically healthy children identified by Lukashevich et al. [6–10] have no full correspondence in the assessment of the EEG of the risk group of children with long-term effects of perinatal CNS lesion. At the age of seven years, they have characteristic instability of modulations of the basic α rhythm, the presence of slow and sharpened forms of activity even in a state of quiet wakefulness.

It was established that, in more than 80% of the children examined, the EEG were represented by two main types. The first type with the occipito-parietal focus of the main α rhythm and an amplitude within 50–100 μV is regarded as mature and formed according to age (described in the literature as the electrographic standard of the norm [11, 12]). The second EEG type is represented by low-amplitude (no more than 50 μV) spatially disorganized asynchronous activity. Less than 20% of the EEG are represented by high-amplitude EEGs with regular forms of activity but without a normally developed occipito-parietal focus of the α-rhythm (as a rule, hypersynchronous, 50–100 μV), and a high-amplitude EEG with a decelerated leading rhythm (in the θ- and Δ bands).

Earlier, these EEG types were assessed in children who, despite a history of perinatal CNS damage, studied at comprehensive school [5]. The aim of this study was to carry out comparative analysis of the identified EEG types in children with different degrees of developmental retardation of the higher mental functions and speech.

METHODS

Children with a history of perinatal CNS damage (predominantly hypoxic–ischemic ones) who were followed up at the clinic of the Institute of the Human Brain of the Russian Academy of Sciences with complaints of increased fatigue, sleep disorders, learning difficulties, including those determined by the retarded development of higher mental functions and speech, disinhibition, hyperactivity, etc. were examined. The children were divided into the following main groups: group 1, preschool and younger children with normal development of the higher mental functions (HMFs) and speech (520); group 2, preschool children with speech disorders and a normal level of development of other HMFs (retardation of speaking rate development, general underdevelopment of speech, 204); group 3, preschool children with combined developmental disorders of the HMFs and speech (mental retardation, early infantile autism, etc., 226); and group 4, schoolchildren attending comprehensive primary schools: 4A, those coping successfully with the comprehensive school curriculum (505) and 4B, those with learning difficulties (dysgraphia and/or dyslexia, attention deficit disorder, etc., 371).

EEG studies were conducted once (using the transverse section method) in 1917 children with ages varying between seven months and ten years: 1041 preschool and younger children and 876 children school.

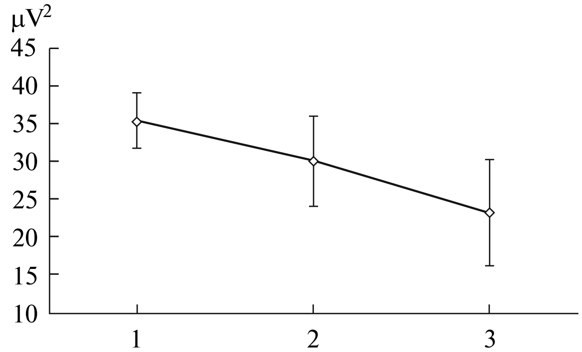

Fig. 1. Comparative analysis of the total EEG α-band power spectra in the risk group of preschool children with a different level of development of higher mental functions (HMFs) and speech. Abscissa, the preschool children group number: (*1*) normal development of HMFs and speech; (*2*) speech disorders and normal other HMFs; (*3*) combined developmental disorders of HMFs and speech. Ordinate, the total α-band spectral power values in all the main EEG derivations (the international 10–20 scheme).

The EEG studies (1295) in 400 children were carried out using the longitudinal section method (longitudinal method). The EEGs were recorded using the Mitsar computer encephalograph. The silver chlorine-bridge electrodes were applied according to the international 10–20 scheme; the recording was made in the following frequency bands: the lower boundary, the time constant 0.1 s; the upper boundary, 50 Hz. The resistance of the EEG electrodes did not exceed 5 kΩ. The recording was made in the monopolar mode in relation to the right and left earlobe silver chlorine electrodes and in the bipolar mode at rest for 2–4 min. The functional load was rhythmic photostimulation at 1–20 Hz. Win EEG as software for EEG processing.

In addition to clinical (visual) analysis, the statistical EEG processing used the method for assessing the power spectra that correlates well with the specificity of the clinical assessment of the EEG parameters [13]. Comparative analysis of the power spectra was carried out according to the following parameters: (1) the Δ band (1–4 Hz); (2) the θ band (4–7 Hz); (3) the α band (8–12 Hz); (4) the β_1 band (12–15 Hz); (5) the β_2 band (15–18 Hz); and (6) the β_3 band (18–25 Hz). The following are the spectrum calculation parameters: the epoch, 4 s; epoch overlapping, 50%; Henning temporary window; the duration of the EEG fragment analyzed at rest with the eyes closed, approximately 1 min. The statistical analysis of the EEG power spectra was carried out with the comparison of different conditions using repeated-measurement two-way ANOVA with the "group of children" factor (the level number is 2 and 3) and the "electrode localization" factor (the level number is 16). The significance of differences in the representation of the EEG types in the groups of children was determined using Student's *t* test.

In order to assess the interhemispheric asymmetry, the difference between the spectral power in the derivations Fp_2–Fp_1, F_4–F_3, F_8–F_7, C_4–C_3, T_4–T_3, P_4–P_3, T_6–T_5, and O_2–O_1 was calculated for the main EEG bands θ (4–7 Hz), α (8–12 Hz), and β_2 (15–18 Hz) in children with retarded development versus group 1 (children with normal development of the HMFs and speech). The significance of differences in asymmetry was assessed using Student's *t* test.

RESULTS

The analysis of variance of the main "group" factor revealed significant differences between the groups of preschool children with different levels of HMF and speech development in the α-rhythm frequency band (8–12 Hz): F (2, 131) = 4.95; ε = 0.1585; $p < 0.01$ (Fig. 1). As seen from the figure, a decrease in the α rhythm's spectral power is observed with a longer delay in development.

Statistically significant intergroup differences in the α-band were revealed when the interaction between the group–localization factors was analyzed: F (30, 1965) = 2.17, ε = 0.1585, $p < 0.001$. The differences between these groups of children in this band were the most pronounced in the occipito-parietal divisions. It is the presence/absence of this α-rhythm focus (but not only its frequency) that was one of the main criteria of the maturity/immaturity of the age-related biorhythm structure in the framework of the clinical analysis when the EEGs of the children were evaluated.

Statistically significant intergroup differences as an interaction of the group–localization factors were also traced in relation to the β_2-band's spectral power at 15–18 Hz: F (30, 1965) = 2.2, ε = 0.3637, $p < 0.001$. The intergroup differences in this band were similarly the most pronounced in the occipito-parietal areas.

In group 1 preschool children with normal development of the HMFs and speech, and a mature low- and high-amplitude EEG type (with the occipito-parietal focus of the α rhythm) was on the whole 85%. The proportion of an immature EEG type significantly decreased to 15% of the number of those analyzed in this group ($p < 0.001$) (Fig. 2).

An increase in the frequency of the immature EEG type was revealed in children with retarded development of HMFs and/or speech as a function of the severity of the impairment. Specifically, in group 2 (children with speech disorders and normal HMFs), the immature EEG type was revealed in 26% of the cases. In group 3 children with a combination of retarded development of HMFs and speech, the percentage of immature EEG reached 55.3% ($p < 0.001$).

The EEG types were also compared in retarded children who showed positive dynamics with the use of the standard methods of correction (pharmacotherapy, logocorrection) and in children who did not benefit much with the use of this approach. It was shown that, in group 2 children with a low effectiveness of the standard approach, the proportion of immature EEG was almost twice as high as in children from this group who showed positive dynamics on this therapeutic regimen: 44.5% against 23.2% (significant differences at $p < 0.001$). In group 3, this ratio was 61.0 to 43.6%, respectively (significant differences at $p < 0.001$).

In communication I, the differences in the distribution of immature EEG between the group of those who coped successfully with the primary school curriculum (4A) and the group of schoolchildren with learning difficulties (4B) were assessed as a tendency [5]. The greater number of the examined schoolchildren demonstrated the significance of these differences at $p < 0.001$. Similarly to group 2 and group 3 preschool children, the proportion of immature EEG in schoolchildren with learning difficulties (4B) and a low effectiveness of the standard methods of correction was significantly higher, compared to those who showed positive dynamics with the standard correction approach ($p < 0.05$).

To put it differently, preschool children and younger schoolchildren who, as shown by the EEG study findings, have an immature developmental biorhythm structure, represent a group of children not easily amenable to correction with the standard means (psychological, logopedic, pedagogical, pharmacological, etc.).

The analysis of the power spectrum asymmetry in the groups of children studied demonstrated significant differences only in the p band in the temporal T_3–T_4 derivations (Fig. 3a, statistical significance $F(1; 33) = 1.93$, $p < 0.038$) and the occipital O_2–O_1 derivations (Fig. 3b, statistical significance $F(1, 33) = 1.05$, $p < 0.078$).

Comparative analysis of the total α-band spectral power values for the right and left hemispheres was carried out in group 1 and 3 children whose level of development maximally differed. In the left hemisphere, significant interhemispheric intergroup differences in spectral power were revealed in the posterotemporal derivation (T_5) and represented by a lower level of α activity in group 3 of retarded children: $F(1, 33) = 8.53$; $p < 0.006$ (Fig. 4). In the right hemisphere, significant intergroup differences in the α band were revealed in a number of derivations: T_4 ($F(1, 33) = 4.07$; $p < 0.05$), T_6 ($F(1; 33) = 5.19$; $p < 0.03$), O_2 ($F(1, 33) = 11.31$; $p < 0.002$) and, on the whole, for the hemisphere ($F(1, 33) = 5.16$; $p < 0.03$). These differences were also expressed by a lower level of α activity in the right hemisphere in group 3 retarded children.

Comparative EEG analysis between first-year pupils aged seven years in the comprehensive school with the effects of perinatal CNS lesion and the normative EEG database for apparently healthy age-matched children (archive data from the laboratory headed by Kropotov; the control group) revealed the following peculiarities. The EEG power spectra in these groups of children differed significantly in all the frequency bands analyzed, both for the group factor and the interaction between the group–localization factors.

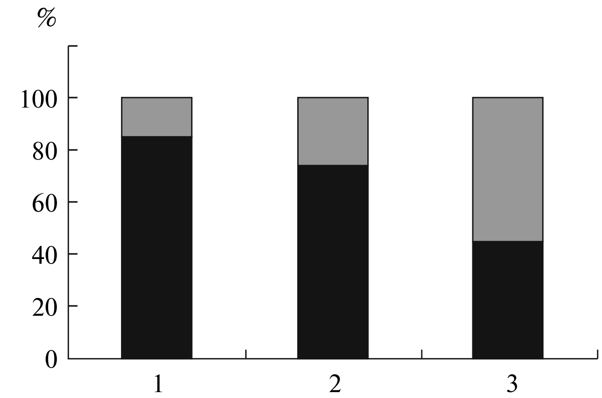

Fig. 2. Distribution of the EEG types: mature (the black part of the columns) and immature (the gray part of the columns) in preschool children with a different level of development of higher mental functions (HMFs) and speech. Abscissa, the groups of preschool children (see Fig. 1). Ordinate, the percentage of detection of the EEG type in the group.

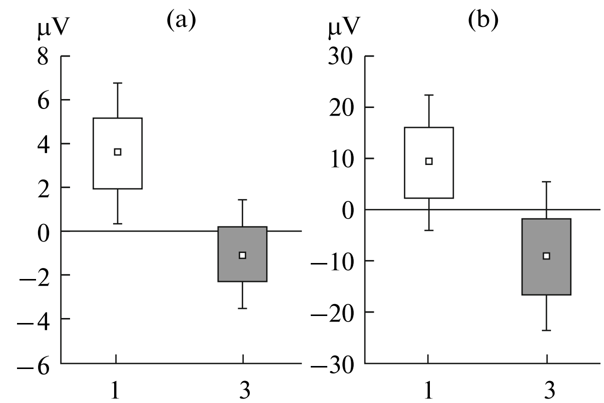

Fig. 3. Interhemispheric asymmetry of the EEG α-band spectral power in preschool children with a different level of development of higher mental functions (HMFs) and speech. Abscissa, the group number of the preschool children at risk: (1) normal development of HMF and speech (the white column); (3) combined developmental disorders of HMF and speech (the black column). Ordinate, the average values and the standard deviations for the statistically significant differences in the interhemispheric asymmetry of the α band in the EEG derivations (a) T_3–T_4 and (b) O_1–O_2.

In particular, the seven-year-old risk group children have higher spectral power values in the θband compared to the control group of healthy individuals in most EEG derivations, except F_3 and C_3. In the α-band, the occipito-parietal focus accounted for the maximum differences in spectral power. In the left hemisphere derivations F_3 and C_3, the intergroup differences had the opposite sign.

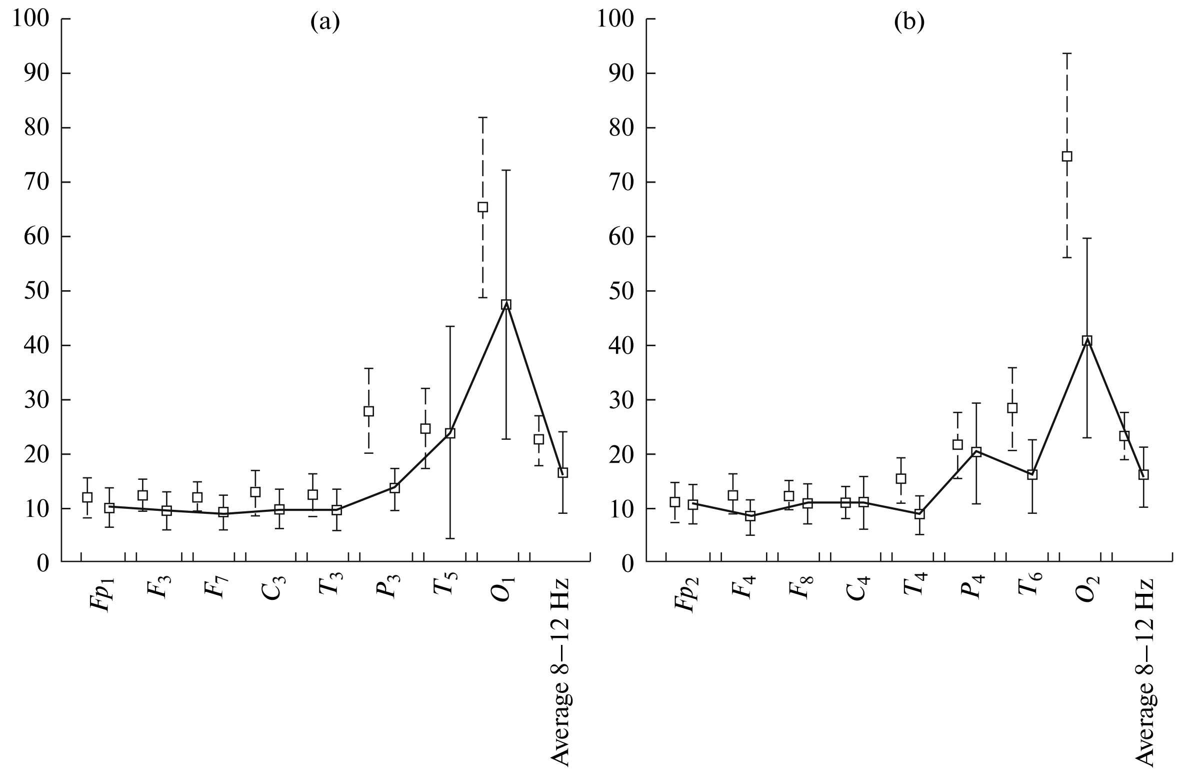

Fig. 4. Comparative analysis of the EEG α-band spectral power in preschool children with a different level of development of higher mental functions (HMFs) and speech. Abscissa, the main EEG derivations according to the international 10–20 scheme in the (a) left and (b) right hemispheres. Ordinate, the average α-band spectral power values in the indicated EEG derivations in group 1 (the dotted line) and group 3 children (the solid line).

In the β_1 frequency band (12–15 Hz), significant differences were observed for many EEG derivations, similarly to the θ band with higher spectral power values in the group of children at risk. And in this band, the inversion of the sign of the intergroup differences was observed in the derivations F_3, C_3 and, in addition, appeared in the derivation P_3.

At higher β-band frequencies (15–18 Hz), the maximum differences in spectral power were observed in the occipito-parietal area as in the α band. Inversion or leveling of the intergroup differences was likewise observed in the left hemisphere, but, in this case, in the series of derivations F_3, T_3, T_5, C_3, and P_3. Smaller intergroup differences with respect to the interaction of the group–localization factors, were observed in the β band at 18–25 Hz in most bioelectric potential derivations with a change in the sign of the interhemispheric asymmetry of spectral power, compared to the other EEG bands. In particular, in the fronto-temporal and centro-parietal derivations, the spectral power values in this EEG frequency band were higher in healthy seven-year-old children, and their considerable increase was observed only in the occipital derivations in the risk group.

The EEG analysis in young (under three years) children examined was limited to the clinical (phenomenological) signs of description due to the age-related difficulties of long-term artifact-free recording. More than 70% of group 1 children with normal psychomotor development had the mature, both high- (50–100 μV) and low-amplitude (less than 50 μV), EEG structure with the occipito-parietal focus of the α rhythm even at an early age. The proportion of high-amplitude immature EEG with the absence of the occipito-parietal focus of the θ- or α rhythm in young children was only 6–9%. In the groups with retarded psychomotor development, the number of immature low-amplitude EEG was significantly higher (54.7% of the children, $p < 0.05$).

As mentioned in communication I, the low-amplitude unorganized EEG type (less than 50 μV with the absence of the α-rhythm occipito-parietal focus) does not change significantly with age, being retained as a type considered as a characteristic of the relative inertness of the brain mechanisms responsible for maturation of the biorhythm structure or indicated immaturity of the integration systems per se [5]. In the longitudinal study, the individual comparison (superposition) of the power spectra in children and the main EEG types described demonstrated the retention of the type as such, despite the change in the quantitative EEG parameters with age.

Age-related dynamics of the types of maturity/immaturity of cortical rhythms in children with different levels of development of higher mental functions (HMFs) and speech (a longitudinal study)

Groups of children	Retention of the initial EEG type with age		Replacement of the immature EEG type by the mature one	
	Absolute number	%	Absolute number	%
Children with normal HMFs and speech ($n = 267$)	239	89.5	28	10.5
Children with the developmental disorders of HMFs and/or speech ($n = 133$)	107	80.5	26	19.5

As seen from the table, the age-dependent change in the immature EEG type, i.e., its maturation in the form of its replacement by the mature EEG type, occurs in an insignificant part of children with long-term effects of perinatal CNS damage (10–20%). In other words, if at the preschool age the EEG is classified as an immature, low-amplitude one, the probability that at later ontogenesis stages it will remain such is very high. The same relationship was also observed regarding the other EEG types described.

DISCUSSION

There are different opinions about the reference normal EEG parameters for young children; however, the α rhythm is considered to play the leading role in the formation of the developmental biorhythm structure after the age of three or four years. As shown by the analysis of the literature, the preference in the choice of the criteria of maturity is given to the frequency parameters; in particular, the α-rhythm frequency is described to be increased (accelerated) with age [1, 7, 9]. The parameters of its spatial organization and the amplitude ranges are not used by the authors as the classification-based developmental criteria of maturity/immaturity of the biorhythm structure, although the importance of these parameters is observed for EEG description [14–16].

Formed on the basis of the clinical phenomenological EEG classification in adults [11, 12], this classification of the types of developmental maturity/immaturity of the brain's bioelectrical activity in the preschool children examined is based on the assessment of both the frequency criteria of the α rhythm and the parameters of its spatial organization (the presence/absence of the occipito-parietal focus), as well as the amplitude range (the low-amplitude range, less than 50 μV or the high-amplitude range, 50–100 μV). In the bipolar transverse EEG mode (from the anterofrontal to the occipital derivations), the clinical physiological determination of the type visually is simple enough.

The fractionality of the quantitative characteristics and more rigorous categorization criteria for detecting a pure type inevitably lead to the EEG of an individual specific child not fitting a certain type. The application of the dichotomic yes/no principle (whether or not the α-rhythm occipito-parietal focus is formed) in describing the developmental EEG structure facilitates the process of assessment of the formal biorhythm structure.

The validity of the revealed phenomenological criteria of classification of the EEG maturity/immaturity types in children was verified by analysis of the EEG power spectra, which showed significant differences between the groups of children with different levels of development of HMFs and speech in the EEG α band with maximum changes in the occipito-parietal area of the cerebral cortex. The adequacy of the choice of the criteria of the classification of maturity/immaturity of cortical rhythms is also confirmed by the data on the significant increase in the proportion of the immature type of cortical rhythms as a function of the degree of severity of the developmental disorders of HMFs and speech in children.

The interhemispheric asymmetry of the EEG rhythms in children with different levels of HMF and speech development is characterized by the presence of significant differences predominantly in the α band and demonstrates a certain reciprocity of relations between the hemispheres at different levels of mental development (inversion of the asymmetry sign when groups 1 and 3 were compared).

The interhemispheric differences between apparently healthy seven-year-old children and those with the normal level of mental development among the children who experienced the effects of perinatal CNS damage are characterized by a decrease in the EEG power spectra of the main bands (θ-, α-, and β) in certain left hemisphere divisions, compared to the right hemisphere in the group of children at risk. At the same time, the power spectra of the main bands in the right hemispheric areas are higher in the group of children at risk. This might be indicative of the greater vulnerability of the left hemisphere affected by the perinatal pathology factors.

Despite the distinct phenomenological (visual) differences, the asynchronous and hypersynchronous types of the immature developmental EEG structure may be combined as the polar points in the dysrhythmia continuum. This continuity allows the diversity of individual EEG to fit in the range between the two poles, retaining the similarity of the scheme to the real process. It is dysrhythmia in which disorganization of biological rhythms due to the early organic cerebral pathology manifests itself according to the principles of chronobiology [17]. In addition to the disorganization of the cortical rhythms, clinicians note the sleep–wakefulness cycle disorders, nonuniform (nonharmonious) mental development with the predominance of signs of underdevelopment of the voluntary sphere, emotional immaturity, etc. in the spectrum of changes in the CNS of children exposed to perinatal pathology.

The longitudinal EEG study (in the same children aged three to ten years) showed that the developmental EEG dynamics described in the literature has its specific features in the group of children at risk with the effects of perinatal CNS damage. In particular, it was shown that the immature type of the cortical rhythm pattern is at high risk of being retained at the later ontogenesis stages. A change in the immature EEG type with age, i.e., its replacement with the mature EEG type, occurs only in 10–20% of children. The insufficient organization of the cortical rhythm patterns in the children examined as a reflection of disorders of the integrative processes in the brain is what comes to the fore compared to a number of other features of bioelectrical activity (pathological forms of activity, polyrhythmia, etc.). This EEG characteristic seems to discriminate between the normal and the abnormal development of perinatal origin: the EEGs that have not been formed according to age (immature) do not acquire a different quality, which is maturity.

The higher prevalence of the immature EEG type in retarded children leads us to predict the formation of possible limitations of the cognitive and emotional–volition spheres in the group of children at risk at the early stages of ontogenesis when the brain's plasticity and the compensatory potentialities of the CNS are higher. This, in turn, allows us to plan preventive measures on the dynamic follow-up or correction of HMFs and speech disorders in order to minimize the negative effects of perinatal CNS damage affecting the learning capabilities and social adaptation of children.

It is known that only 30% of the first-year pupils of primary school have functionally mature, for their age, cortexes and regulatory structures, which ensures the development of higher mental functions and voluntary behavior sufficient and necessary for them to master the curriculum [1, 5, 8–10, 18]. Various risk factors of school maladaptation have been revealed in 60% preschool children of this age [19]. According to psychological data, only 17% of seven-year-olds are ready to study at school [20]. In 52–73% of preschool children, prospective primary-school pupils, the HMFs, including the emotional–volitional sphere, auditory–speech memory, etc., have not been formed at the age-specific normal level [21].

Naturally, the presence of the immature EEG type in a child at risk is not an absolute criterion restricting his or her psychomotor development. On the one hand, this is consistent with the known concept of EEG nosological nonspecificity; and on the other hand, it reflects only part (although an important one) of the cerebral mechanisms of the formation of the structure of mental activity. Asynchronous EEGs are also recorded in intellectually sufficient children with neurotic disorders, the hyperactivity syndrome, etc., in the presence of a steady increase in desynchronizing influences on the cortex by the nonspecific structures of the brainstem. This is a risk factor that can be identified as early as the age of three years and for which an adequate strategy of treatment, teaching, and social adaptation could be selected [22]. It is this approach that allows the risks of the formation of problems in children with the effects of perinatal CNS damage to be minimized.

CONCLUSIONS

Based on the data on the clinical and physiological analysis of the long-term effects of perinatal damage of the nervous system, one of the main risk factors of learning difficulties and socializing is the immaturity (compared to the age-specific normal level) of the biorhythm structure as a manifestation of the underdevelopment of, or damage to, the brain structures and disruption of the integrative activity of the CNS. The absence of the α-rhythm focus in the preschool children examined was determined as the criterion of immaturity of the developmental biorhythm structure.

A significant increase in the proportion of the immature EEG type according to the degree of severity of deviations in the development of higher mental functions and speech of perinatal origin has been revealed. Taking into account the features of the developmental dynamics of the immature EEG type in the children studied (demonstrated in the longitudinal study), the presence of this type of early in life is a marker of the risk of disordered development of mental processes, the emotional–volitional sphere, and social adaptation.

REFERENCES

1. Farber, D.A. and Dubrovinskaya, N.V., Functional Organization of Developing Brain: Age-Related Features and Certain Regularities, *Fiziol. Chel.,* 1991, vol. 17, no. 5, p. 17.

2. Vedeneeva, L.S., Soroko, S.I., and Shepoval'nikov, A.N., Statistical Structure of Interaction between the Main EEG Components in Schoolchildren, *Fiziol. Chel.,* 1998, vol. 24, no. 1, p. 5 [*Hum. Physiol.* (Engl. Transl.), 1998, vol. 24, no. 1, p. 1].

3. Bekshaev, S.S., Soroko, S.I., and Vasilevskii, N.N., Regularities Underlying the Maintenance of Dynamic Stability of the EEG Frequency Bands in Humans, *Fiziol. Chel.,* 1988, vol. 14, no. 4, p. 545.

4. Peresleni, L.I., Rozhkova, L.A., and Ryabchikova, N.A., About the Neurophysiological Mechanisms of Atten-

tion Disorders in Children, *Zh. Vyssh. Nerv. Deyatel.,* 1990, vol. 40, no. 1, p. 37.

5. Kozhushko, N.Yu., Developmental Features of the Formation of the Brain Bioelectrical Activity in Children with Remote Consequences of a Perinatal Lesion of the CNS: I. Spontaneous Activity, *Fiziol. Chel.,* 2005, vol. 31, no. 1, p. 5 [*Hum. Physiol.* (Engl. Transl.), 2005, vol. 31, no. 1, p. 1].
6. Lukashevich, I.P., Machinskaya, R.I., and Fishman, M.N., Diagnosis of the Functional State of the Brain of Younger Schoolchildren with Learning Difficulties, *Fiziol. Chel.,* 1994, vol. 20, no. 5, p. 34.
7. Machinskaya, R.A., Lukashevich, I.P., and Fishman, M.N., Dynamics of Brain Electrical Activity in 5- to 8-Year-Old Normal Children and Children with Learning Difficulties, *Fiziol. Chel.,* 1997, vol. 23, no. 5, p. 5 [*Hum. Physiol.* (Engl. Transl.), 1997, vol. 23, no. 5, p. 517].
8. Bezrukikh, M.M., Machinskaya, R.I., and Sugrobova, G.A., Differentiated Influence of the Functional Maturity of the Cortex and Brain Regulatory Structures on the Characteristics of Cognitive Activity in 7–8-Year-Old Children, *Fiziol. Chel.,* 1999, vol. 25, no. 5, p. 14 [*Hum. Physiol.* (Engl. Transl.), 1999, vol. 25, no. 5, p. 510].
9. Lukashevich, I.P., Machinskaya, R.I., and Fishman, M.N., Cerebral Neurophysiological Mechanisms of Learning Disabilities in Children: Structural Analysis of the EEG, *Fiziol. Chel.,* 1998, vol. 24, no. 1, p. 16 [*Hum. Physiol.* (Engl. Transl.), 1998, vol. 24, no. 1, p. 11].
10. Rozhkova, L.A., EEG Spectral Power of Young Schoolchildren with Perinatal Pathology of the CNS, *Fiziol. Chel.,* 2008, vol. 34, no. 1, p. 28 [*Hum. Physiol.* (Engl. Transl.), 2008, vol. 34, no. 1, p. 22].
11. Zhirmunskaya, E.A., *V poiskakh ob"yasneniya fenomenov EEG* (In Search for the Explanation of the EEG Phenomena), Moscow, 1996.
12. Zhirmunskaya, E.A. and Losev, V.S., *Elektroentsefalografiya v klinicheskoi praktike* (Electroencephalography in Clinical Practice), Moscow, 1997.
13. Zenkov, L.R., *Klinicheskaya elektroentsefalografiya s elementami epileptologii* (Clinical Electroencephalography with the Elements of Epileptology), Moscow: MED-Press-Inform, 2002.
14. Bondar', A.T. and Fedotchev, A.I., Concerning the Amplitude Modulation of the Human EEG, *Fiziol. Chel.,* 2000, vol. 26, no. 4, p. 18 [*Hum. Physiol.* (Engl. Transl.), 2000, vol. 26, no. 4, p. 393].
15. Grindel', O.M., The Optimal Level of EEG Coherence and Its Significance in the Assessment of the Functional State of the Human Brain, *Zh. Vyssh. Nerv. Deyatel.,* 1980, vol. 30, no. 1, p. 62.
16. Livanov, M.N., *Prostranstvennaya organizatsiya protsessov golovnogo mozga* (Spatial Organization of the Brain Processes), Moscow: Nauka, 1972.
17. Arushanyan, E.B., Chronobiological Nature of Disorders of the Brain Cognitive Activity, *Zh. Neurol. Psikhiatr. im. S.S. Korsakova,* 2005, vol. 105, no. 11, p. 73.
18. Machinskaya, R.I., Functional Maturation of the Brain and Formation of the Neurophysiological Mechanisms of Selective Voluntary Attention in Young Schoolchildren, *Fiziol. Chel.,* 2006, vol. 32, no. 1, p. 26 [*Hum. Physiol.* (Engl. Transl.), 2006, vol. 32, no. 1, p. 20].
19. Bezrukikh, M.M., Trudnosti obucheniya detei v nachal'noi shkole (Difficulties of Teaching Children at Primary School), Moscow: Astrel', 2004.
20. Gutkina, N.I., Psikhologicheskaya gotovnost' k shkole (Psychological Preparedness for School), St. Petersburg: Piter, 2004.
21. Novikova, G.R., The State of Higher Mental Functions in Children Beginning the First Year at Comprehensive School as Estimated by the Results of Neuropsychological Survey, *Defektologiya,* 2000, no. 2, p. 51.
22. Kozhushko, N.Yu., The Mechanisms of Developmental Disorders of Higher Mental Functions and Speech in Children and the Possibilities of Their Correction, *Doctoral Sci. (Biol.) Dissertation,* St. Petersburg, 2009, p. 32.