Interhemispheric Interaction in Children with Autonomic Dysfunction of the Sinus Node

L. I. Kolesnikova, N. V. Korolyeva, O. V. Bugun, S. I. Kolesnikov, and V. V. Dolgikh

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 148, No. 9, pp. 262-265, September, 2009
Original article submitted November 11, 2008

Electroencephalography was performed in 7-8- and 9-10-year-old pupils. Control group consisted of healthy children; experimental group consisted of children without signs of grade IV and V sinus arrhythmia at the age of 7-8 years, but with grade IV and V sinus arrhythmia at the age of 9-10 years. In primary school-aged children (7-8 years), manifestation of marked sinus arrhythmia is associated with disturbances in age-specific dynamics of interhemispheric interaction and with the formation, at the initial stage, of a rigid integrated system primarily due to functional intrahemispheric connections, the major contribution being made by the posterior associative cortical areas.

Key Words: *interhemispheric coupling; bioelectrical activity of the brain, sinus arrhythmia*

The mechanisms underlying the formation of disturbances in the cardiovascular system in children with neurocirculatory dystonia is a complex and important problem of pathology of the autonomic nervous system in children. This clinical entity includes a syndrome of electrocardiographic disorders; high grade sinus arrhythmia is a variant of these disturbances [1].

Disintegration of functional processes in the brain and deficiency in its adaptive mechanisms are common phenomenon typical of cerebral processes disorders. Changes or discordance in normal interhemispheric interaction, in turn, can be a pathogenesis factor of autonomic suprasegmentary disorders.

The objective of our study was to analyze the ratio between parameters of bioelectrical activity in hemispheres of children during the development of marked and pronounced (grades IV and V) sinus arrhythmia.

MATERIALS AND METHODS

We examined 20 children (12 boys and 8 girls), 1st form (7-8 years) and 3rd form (9-10 years) pupils.

Research Center of Family Health Protection and Human Reproduction Problems, Siberian Division of the Russian Academy of Medical Sciences, Irkutsk, Russia. ***Address for correspondence:*** koroleva-mail@mail.ru. N. V. Korolyeva

The control and experimental groups were formed retrospectively taking into account the health status and ECG data.

The control group included 8 apparently healthy children. The experimental group consisted of 12 children without grade IV and V sinus arrhythmia at the age of 7-8 years, but with grade IV and V sinus arrhythmia at the age of 9-10 years. The following EEG phenomena were observed in these children at the age of 7-8 years: signs of partial right bundle branch block (6 cases) and shortened *PQ* interval (1 case). At the age of 9-10 years these children had signs of partial right bundle branch block (6 cases), grade I atrioventricular block (1 case), grade II type I sinoatrial block (impermanent, disappearing during test with physical exercise; 3 cases), wandering atrial pacemaker (3 cases), and shortened *PQ* interval (1 case).

ECG study was performed using Fukuda Denshi FX-3010 electrocardiograph. ECG was recorded and analyzed routinely; the interval duration was measured in standard lead II [4,6].

EEG was recorded routinely using a 34-channel Neurotravel electroencephalograph [3]. The electrodes were placed on the head according to "10-20" international scheme; monopolar leads with averaged electrode (AV) were used. Analysis of mean effective

0007-4888/09/1483-0374

spectrum frequencies at the state of calm wakefulness from leads F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, and T6 was performed.

The results were statistically analyzed using Statistica 6.0 (StatSoft® Inc.) software, using Pearson coefficient (R) and ratio significance test (Z). Correlation relationship ratio was estimated from the number of possible correlations (13 for each lead point, 81 for all leads integrally; 21 for intrahemispheric and 49 for interhemispheric correlation relationships).

RESULTS

Correlation analysis of different mean effective frequencies of EEG spectrum in different areas of the left and right hemispheres showed that in healthy 7-8-year-old children the structure intercortical relationships is weakly integrated and is presented by 8.8% correlation relationships. By the age of 9-10 years, the structure of intercortical interactions in healthy children becomes more complex, which is seen from a significant (p<0.05) increase in correlation relationships up to 45.1%; the contribution of both intra- and interhemispheric relationships significantly increases (Fig. 1).

Generally, the period from 7 to 10 years is the stage of ontogeny, when structural and functional organization of intercortical, particularly interhemispheric, and corticosubcortical interaction changes dramatically [5,8]. At the same time, along with intensive development of central mechanisms, integral activity of the brain is still maintained by insufficiently integrated functional system [7], while intercentral interactions are instable [2]. It is associated with structural and functional immaturity of the brain, on the one hand, it includes certain plasticity mechanism, on the other, and we believe that realization of this mechanism promotes the formation of optimal level of intercentral interactions at this stage of ontogeny.

The structure of intercortical interactions in children from the experimental group at the age of 7-8 years is more integrated and the ratio of correlation relationships is 64.8%, which significantly (p<0.05) surpassed the corresponding parameter in age-matched healthy children. By the age of 9-10 years, it becomes more complex and the number of correlations (79.1% correlation) significantly surpassed that in 9-10-year-old healthy children and in 7-8-year-old children in the experimental group (p<0.05). In the experimental group, only the number of interhemispheric functional connections increased with age, while the ratio of intrahemispheric connections is already increased by the age of 7-8 years and does not significantly change at 9-10 years (Fig. 1).

Excessive strengthening of statistic interaction between parameters of brain activity with the formation of a rigid steady mechanism of its self-regulation gives reason to consider these interhemispheric interactions as reflection of "hyperadaptation" [9] determining the appearance of a stable "prepathological system" in the brain; long-term preservation and stabilization of this system promotes its progressive development.

Along with total increase in the number of correlation, the contribution of functional connections formed by the fronto-anteriofrontal area of the left hemisphere, frontocentral area of the right hemisphere, and occipital areas of both hemispheres increases in control children by the age of 9-10 years (p<0.05, Fig. 2), *i.e.* activity of both anterior and posterior cortical areas increases in a balanced manner.

The ratio of formed functional connections in children of the experimental group at the age of 7-8 years significantly (p<0.05) surpassed the control value in all areas except central ones and also right frontal and left anteriofrontal areas. Moreover, the number of functional connections formed by the right and left anterior frontal areas, in this case significantly (p<0.05) increases at the age of 9-10 years (Fig. 3).

It was noted, that 7-8- and 9-10-year-old children of the experimental group are characterized by the same significant (p<0.05) differences in the balance of functional connection number formed by different areas of the cortex in comparison with 9-10-year-old children from the control group.

It should be noted that in children of the experimental group the ratio of functional connections formed by parieto-dorsotemporal areas of both hemispheres was significantly (p<0.05) higher than in 7-8- and

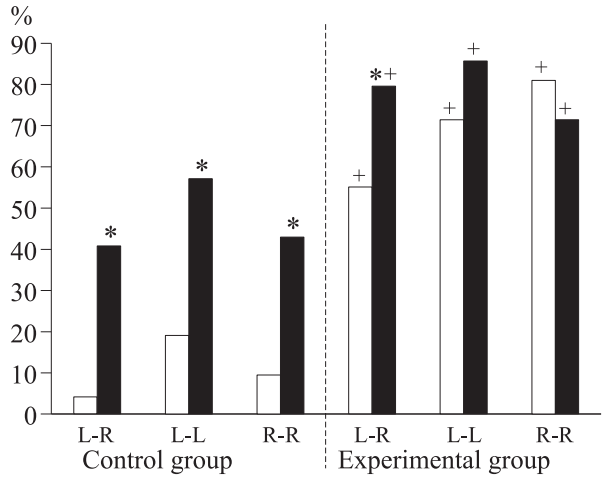

Fig. 1. Age distribution of ratio values of intrahemispheric and interhemispheric correlation relationships between mean effective EEG frequencies in children from control and experimental groups. L-R: interhemispheric correlation relationships, L-L: left hemisphere correlation relationships, R-R: right hemisphere correlation relationships. p<0.05 compared to: *7-8-year-old children, +control group. Light bars: 7-8-year-old children, dark bars: 9-10-year-old children.

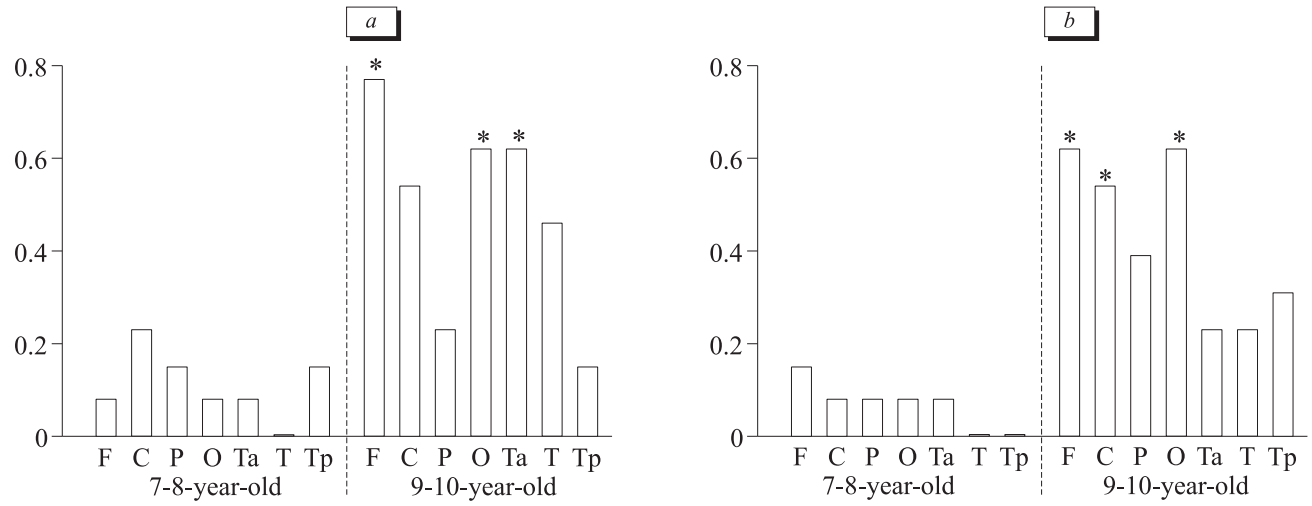

Fig. 2. Distribution of ratio values of intrahemispheric and interhemispheric correlation relationships between mean effective EEG frequencies in different regions of left (*a*) and right (*b*) hemispheres in control group children. Here and on Fig. 3: F: frontal, C: central, P: parietal, O: occipital, Ta: anterior temporal (F7, F8), T: middle temporal (T3, T4), Tp: posterior temporal (T5, T6) areas. **p*<0.05 compared to the same hemisphere in 7-8-year-old children.

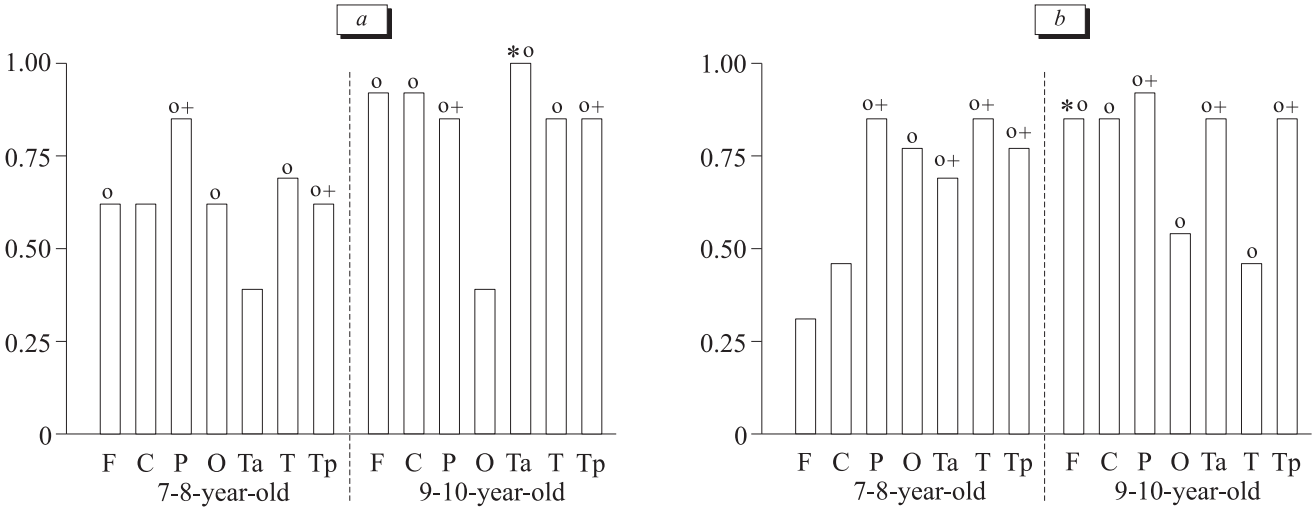

Fig. 3. Distribution of ratio values of correlation relationships formed by mean effective EEG frequencies in different regions of the left (*a*) and right (*b*) hemispheres in children of the experimental group. *p*<0.05 compared to: +9-10-year-old controls in the same hemisphere, °7-8-year-old controls in the same hemisphere.

9-10-year-old controls. It indicates increased activity of the dorsal associative cortex area and it predominant involvement in the functional integration system, which is already formed at the age of 7-8 years, *i.e.* at the early stage of the formation of pronounced sinus arrhythmia.

Assessment of interregional interhemispheric asymmetry of functional connections represented in terms of mean interhemispheric difference in ratio of functional connections formed by each area showed that this value is significantly ($p<0.05$) higher in the experimental group and tended to increase with age in the control group (from 0.06±0.03 to 0.15±0.05). This, in turn, provides intensification of certain cortex area specialization. At the same time, this parameter in the experimental tended to decrease from 0.18±0.04 to 0.13±0.03, which is probably associated with exhaustion of resources of previously increased specialization essential for adequate adaptation of the neurophysiological system under conditions of its increased integration.

Thus, the development of pronounced sinus arrhythmia in primary school-aged children is associated with disturbances in age-specific dynamics of interregional interhemispheric interactions and with the formation (at the stage preceding functional disorders) of a rigid integrated system (primarily due to intrahemispheric functional connections), the major contribution being made by the posterior associative cortical areas.

REFERENCES

1. *Autonomic Disturbances: Clinical Signs, Treatment, Diagnostics* [in Russian], Ed. A. M. Vein, Moscow (2000).
2. L. S. Vedeneeva and S. I. Soroko, *Fisiol. Chel.*, **25**, No. 4, 51-59 (1999).
3. L. R. Zenkov, *Clonical Electroecephalography (with Epileptology)* [in Russian], Taganrog (1996).
4. M. B. Kuberger, *Textbook on Clinical Electroencephalography in Children* [in Russian], Leningrad (1983).
5. V. P. Leutin and E. N. Nikolaeva, *Functional Asymmetry of the Brain: Myths and Reality* [in Russian], St. Petersburg (2005).
6. M. K. Oskolkova and O. O. Kupriyanova, *Electrocardiography in Children* [In Russian], Moscow (2001).
7. V. A. Tolstova and E. V. Strelnikova, *Fisiol. Chel.*, **25**, No.4, 60-70 (1999).
8. D. A. Farber, T. G. Beteleva, A. S. Gorev, *et al., Physiology of Child Development: Theoretical and Application Aspects* [in Russian], Ed. M. M. Bezrukikh and D. A. Farber, Moscow (2000).
9. M. N. Tsitseroshin, A. A. Pogosyan, E. I. Galperina, *et al., Fisiol. Chel.*, **26**, No. 6, 20-30 (2000).