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**THE BASIS FOR APPLICATION OF THE METHOD OF DYNAMIC PROPRIOCEPTIVE CORRECTION IN THE RESTORATIVE THERAPY OF PATIENTS WITH INFANTILE CEREBRAL PARALYSIS IN THE RESIDUAL STAGE (ОБОСНОВАНИЕ МЕТОДА ДИНАМИЧЕСКОЙ ПРОПРИОЦЕПТИВНОЙ КОРРЕКЦИИ ДЛЯ ВОССТАНОВИТЕЛЬНОГО ЛЕЧЕНИЯ БОЛЬНЫХ С РЕЗИДУАЛЬНОЙ СТАДИЕЙ ДЕТСКОГО ЦЕРЕБРАЛЬНОГО ПАРАЛИЧА)****K. A. SEMYONOVA**

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*A new rehabilitation therapy's method is expounded here which was applied in the treatment of patients with infantile cerebral paralysis in the residual stage. The method is based on the proprioceptive correction by means of "Adeli-92" device – the modification of spaceman's overalls used in conditions of weightlessness. The device allows to intensify the afferent proprioceptive flow which control the motility through the central structures and to normalize it to some extent. A positive clinical effect was observed in 70 % of cases. It manifested in appearance of both walking capacity and self-service ability. The positive effect of the method was reflected in the electroencephalographic, electroneuromyographic and follow-up findings, as well as in the results of examination of the vestibular system,*

If the adequate methods of restorative therapy are applied in the treatment of children with infantile cerebral paralysis from the very first weeks of their lifetime, it leads practically to full recovery in 65-80 % of cases. However, the perinatal cerebral affection can be so severe that it is impossible to effect the desired result even in the case of an early treatment of a child, needless to say about its therapy starting at the age of one year. And at the age of 2-3 years such children already have malformations, contractures formed on the basis of non-reduced tonic reflexes, and in the course of several years they become handicapped persons. The effect of pharmacotherapy, physiatrics, massage, physical training is not great with them, and, then, the basic methods applied are plaster bandage and orthopedic surgery which are far from effecting the desired result [6,11,18].

It was in the department of restorative therapy of children with cerebral paralysis attached to the Research Institute of Russia's Academy of Medical Science that a new method of restorative therapy of patients with infantile cerebral paralysis in the late residual stage was worked out. By means of this method it is possible to make a correction of motor and speech pathology not only with children of any age suffering from such a disease, but also with adolescents and youths.

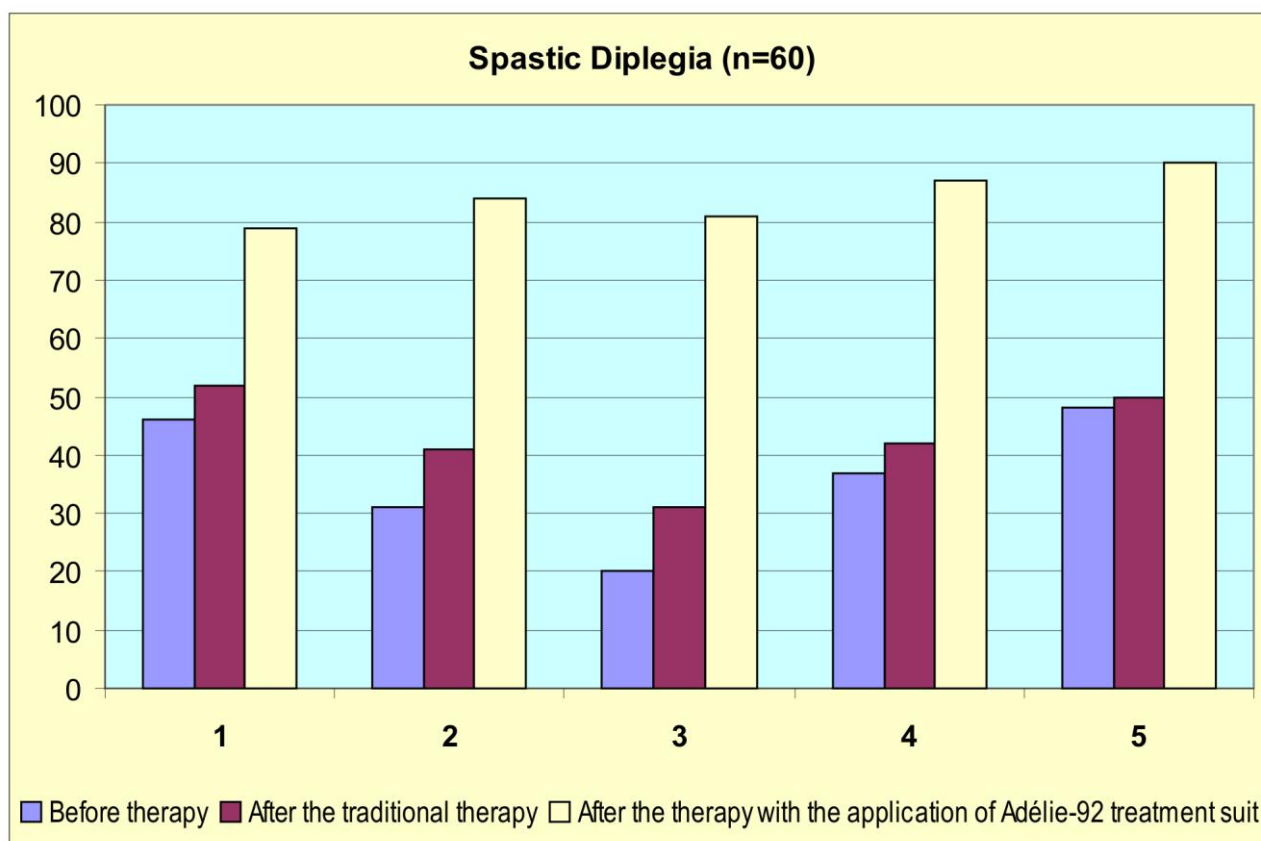
The method which we call 'dynamic proprioceptive correction' (DPC) is based on the principle of the simultaneous remedial effect of the afferent vestibulo-proprioceptive flow arriving in the central structures of a motor analyzer during movement from all points of the musculoskeletal system performing the function of antigravity. For this purpose it is applied "Adeli-92", a treatment suit, worked out on the basis of the "Penguin" cosmonautic overalls which is used by cosmonauts in space flights. For lack of such overalls in conditions of weightlessness hypotrophy of muscles of limbs, osteoporosis of legs, and apraxia of ambulation develop as a result of complicated changes in the system of antigravity. The application of the 'Penguin' overalls reduces such phenomena to minimum [2, 3]. As to patients with infantile cerebral paralysis, the principal pathology of the motility is also bound up with a disturbance of the antigravity system, but in contrast to conditions of weightlessness the disturbance shows itself in inability of the function which is to counteract the influence of a gravitational field [4, 5, 7, 12-14, 21].

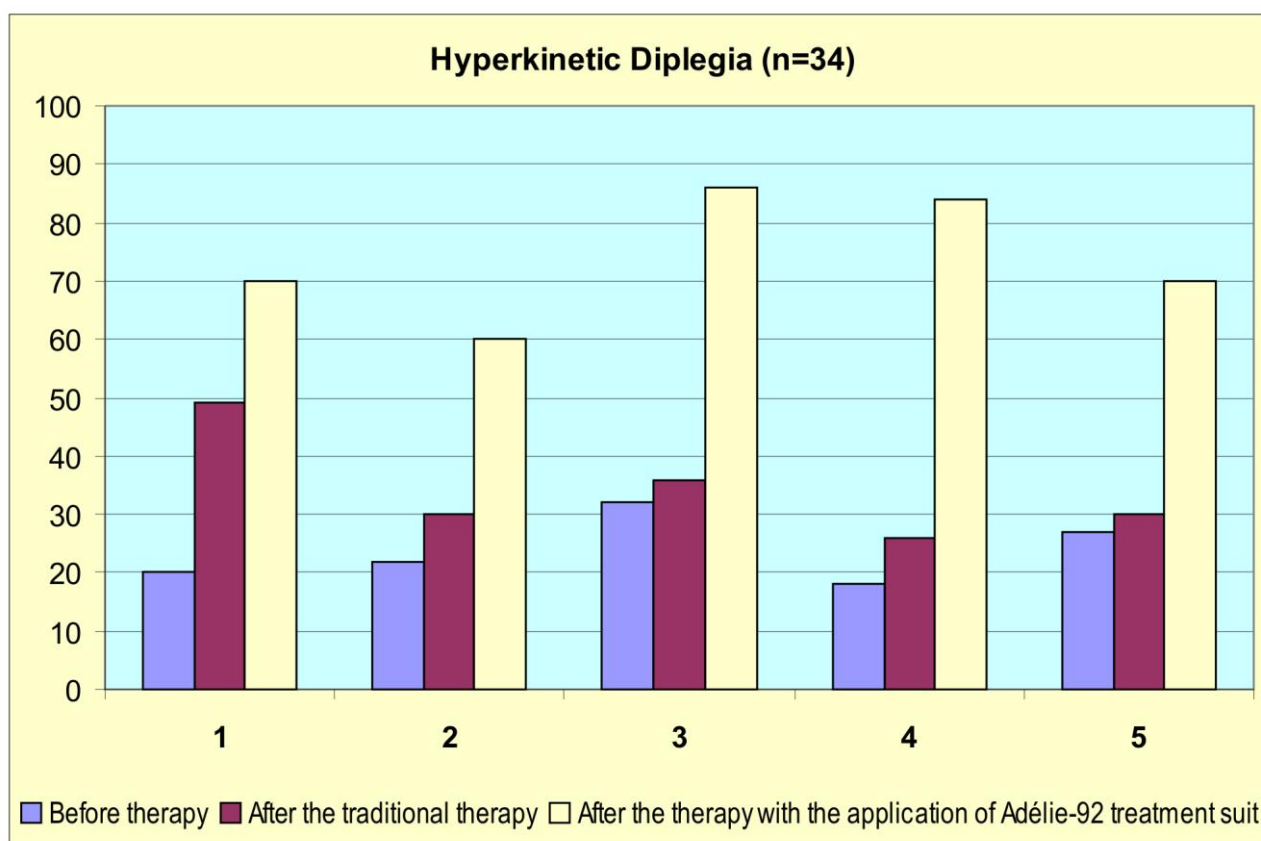
The "Adeli-92" treatment suit has a system of linking rods which facilitates the weakening of the patient's pathologic synergism, the rehabilitation of his physiologic muscular synergism, and the creation of such a load on the antigravity musculature which approximates to the standard to some extent. Then, the afferent vestibuloproprioceptive flow will be normalized on this basis [1, 2, 13, 14]. The thesis put forward by I.M.Sechenov [15], P.K.Anokhin [1], L.A.Orbeli [10] that the formation and development of a movement happen in the course of the movement itself proves correct in this light. Thus, if a healthy child when learning to write needs to make hundreds of monotonous movements in order to succeed in writing a good letter with a correct and semiautomatic

movement, with a patient with infantile cerebral paralysis the process of mastery, reproduction, gradual performance and consolidation of the scheme of any movement which is unfamiliar to him would happen on the basis of a considerably more protracted, proprioceptive flow subject to permanent correction emerging from movement and being regulated by the movement itself on the principle of the inverse afference [4, 11, 12, 20].

To this end, first of all, it is necessary to overcome the pathological motor stereotype which has been formed, but a stable overcoming and a limitation of its possible renewal need simultaneous long enough correction of the vestibuloproprioceptive flow arriving from all segments of the body, and not successive, phased correction of their position as is in the routine work of a methodologist of exercise therapy or when plastering. A new "afferent framework" should be created on the basis of a "muscular framework" corrected in the therapeutic suit of "Adeli-92", maximum approximated to the standard and now determined by other biomechanical bonds of the musculoskeletal system. These new biomechanical bonds are controlled by the antigravity system; a flow of vestibuloproprioceptive afference makes for its structures, now conforming to the norma more than before the application of the therapeutic suit. In the terrestrial gravitational field the new biomechanical bonds above create other schemes of movement in the patient's body as well.

The results of the health effect of the DPC method in the case of patients with the most widespread and severe type of infantile cerebral paralysis are shown in the Figure 1. The diagram indicates first of all that the mastering of different postures which were difficult or imperfect to the patient, and their performance whether moving or not become more probable than under the circumstances of the traditional therapy.





**Figure 1. The effectiveness of application of the Adeli-92 treatment suit of in patients with infantile cerebral paralysis in the late residual stage**

- 1 - Formation and holding of the posture in a sitting position; 2 - Ability of righting the torso in an upright position;  
3 - Ambulation without assistance; 4 - Self-service; 5 - Speech (decrease in dysarthria)

At the same time the muscle tone decreases with patients, and more and more possibilities offer to make voluntary hand movements which (and also the articulation musculature) the action of the linking rods of "Adeli-92" does not affect. Accordingly, the possibilities of self-service and speech become more ample (the dysarthria decreases), the social adaptation of a patient increases.

This kind of changes in the motility of patients can be estimated when taking into account the neurophysiological shifts which arise from the effect of the DPC on the most important element of the vestibular system.

In fact, instability of the antigravity system was observed with all the patients whose diagrams are presented in the Figure 1. It could be judged by the change in the activity of the vestibular nystagmus – which is one of the most important appearance of the activity of the antigravity system – in response to a proprioceptive stimulation. The normalization of this parameter was indicative of the ability of a patient to keep his balance and to find his bearings in space after the course of treatment by means of the DPC [2, 13].

Non-coordination of the matched work of the labyrinths was observed with 80 % of patients. It told on the pathology of distribution of the muscular tonus both of the left half and of the right one of the body, and hence, the disorder of symmetrical course of statokinetic reactions. Under the effect of the DPC the matched work of the labyrinths was restored which secured the adequacy of redistribution of the muscular tonus in conditions of statics and locomotion [5, 21].

Abnormal emaciation of the vestibular nystagmus was observed with all the patients, and, then, it considerably decreased during the course of the DPC which was accompanied by more coordinated performance of statomotor acts.

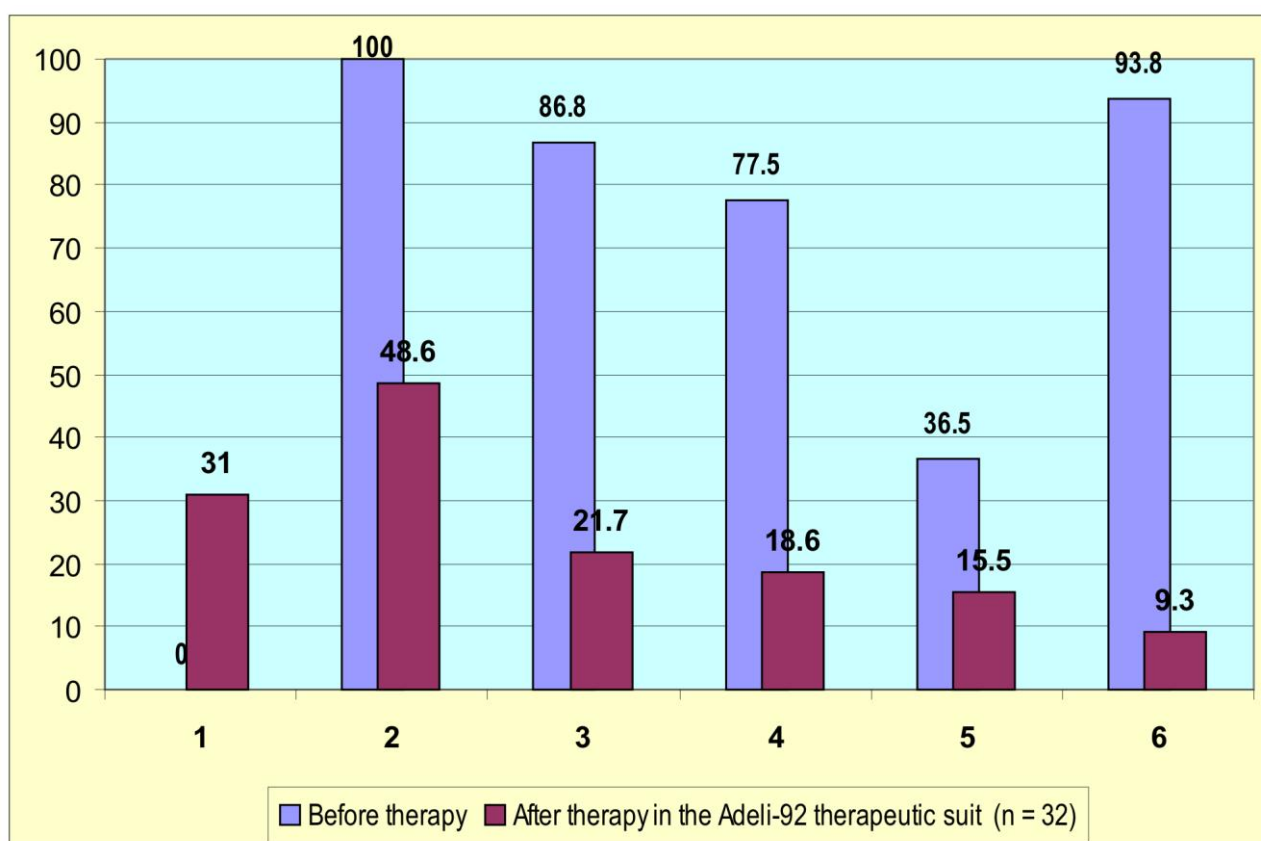
Thus, correction goes on under the effect of the DPC in respect of almost all impaired functions of the vestibular system of the patients with infantile cerebral paralysis.

The antigravity system and the whole complex of postural reflexes are to a considerable degree controlled by the reticular formation of the trunk and of the midbrain. The reticular formation of the midbrain is directly connected with righting reflexes.

If the cortical control weakens by any reason, the stimulation of the medial parts of the reticular formation of the medulla oblongata causes inhibition of the motor functions; the stimulation of the lateral parts of the descending reticular formation of the medulla oblongata leads to alleviation of a movement. In proportion as the cortical control weakens, these trunk reactions become more energetic and take on an independent significance [8, 9, 16, 19, 22, 23].

The diaphanoscopical findings and the data of the neurosonographic survey and tomographic examination point to the fact that the enlargement of the subarachnoid cavities which testifies to atrophic processes in the brain tissue is observed with 50-70 % of children suffering from infantile cerebral palsy; there is no doubt that it reduces the possibility of the cortical control of the activity of trunk structures.

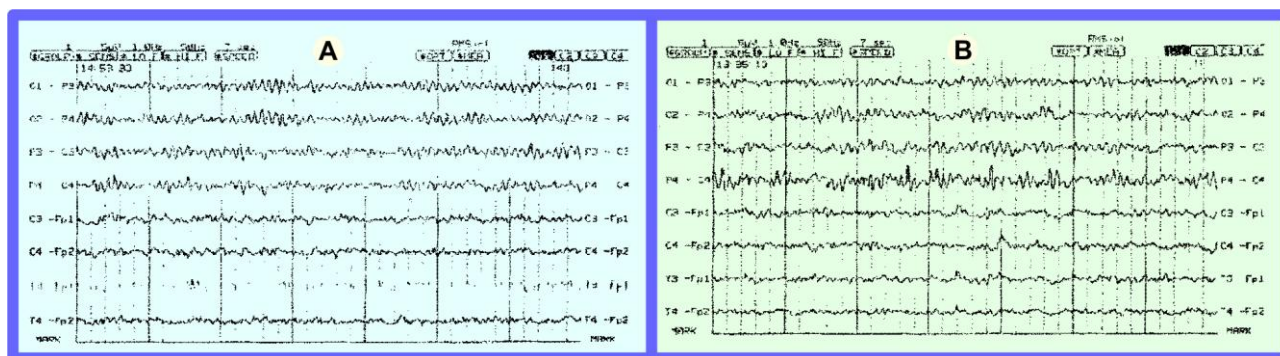
The electroencephalographic (EEG) findings also point to the retardation of the cortical electrogenesis. Before the beginning of the DPC course, general cerebral changes testifying to irritation of the subcortical both diencephalic and mesodiencephalic structures, symptoms of decline in the functional activity of the cortex, regional asymmetries primarily located in the rear parts of the brain were observed with all patients, parallel with the continuing principal cortical rhythm (Fig. 2). Besides, considerable reduction of the spectral power of alpha rhythm and increase in spectral power of theta rhythm were observed.



**Figure 2. Functional state of the brain according to the EEG results (in %) with patients suffering from various types of infantile cerebral paralysis before and after therapy in the Adeli-92 therapeutic suit of ( $n = 32$ ).**

- 1 – EEG within the limits of age standards;
- 2 – abnormalities in the cortical electrogenesis;
- 3 – dysfunction of the mesodiencephalic cerebral structures;
- 4 – decline in the functional activity of the cortex;
- 5 – asymmetric changes of EEG (regional and interhemispheric asymmetries);
- 6 – disturbance of zone differences.

The failure of the cortical control which stimulates the pathologic activity of the structures of reticular formation becomes apparent, in particular, through one of the main syndrome of infantile cerebral palsy: through the normal or almost normal muscular tonus in lying position and the sharp pathologic tonic reaction (mainly in case of the antigravity musculature) in erect position [11, 30]. Under the effect of the DPC, this syndrome begins to decrease or wears off. No doubt, it is connected with the normalization of the cortical control and, accordingly, with the decrease in the activity of the trunk structures. The EEG findings (see above) confirm the well-founded nature of this assertion; and the same can be proved by the somatosensory evoked potentials as well: judging from their indexes obtained in the course of background examination, considerable decrease both in thalamocortical impulses and in the activity of the motor centers of the cortex could be observed. Subsequently, a therapeutic suit of "Adeli-92" was put on the patient, and for 30-40 minutes he walked in it making various movements easy for him. Then, the examination was repeatedly carried out. Smoothing of the intrahemispheric asymmetries was revealed by means of EEG, and with a number of patients – decrease in the pathologic activity of the subcortical structures was ascertained, and with the majority of patients – short-term normalization (or tendency towards it) of the zone distribution of bioelectrical activity, increase in the spectral power of alpha rhythm and decrease in the power of theta rhythm were noted (Figure 3).



**Figure 3. The electroencephalogram (EEG) of a 14-year-old patient, named V, who suffers from spastic diplegia.**

**A** – before therapy: unstable, irregular alpha rhythm, frequency 9-10 Hz, amplitude 30-40 mkV, no expressed modulations, zone differences smoothed; in the parietocentral parts asymmetry is noted in respect of frequency and amplitude parallel with appearance of some pathological signs to the right;

**B** – after the first treatment of 30 minutes' duration in the "Adeli-92" treatment suit: clearly marked modulated alpha rhythm, frequency 10 Hz, amplitude 50 mkV, normalization of zone differences, disappearance of pathological asymmetries.

At the same time, according to the observed data with respect to the somatosensory evoked potentials, the intensity of the thalamocortical impulses and the functional activity of the motor zones of the cortex increased. These changes remained for several hours. However, later on, all the in-

dexes returned to the initial point. Nevertheless, by the end of the whole course, they increased anew to some extent, but for this once in a stable way.

Taking into account the data adduced above, the mechanism of the effect of the DPC method can be shown as follows:

In 1989, the Research Institute of Brain attached to Russia's Academy of Medical Science completed to explore cytoarchitectonics of various parts of the cortex [17]. The exploration showed that in the case of patients with infantile cerebral paralysis the IV. premotor cortical shell (the cells of which are considerably smaller than the normal ones) remained together with other development defects in the motor and premotor cortex. The IV. cortical shell of a healthy man reduces when he is 4-5 years old. Insufficiency and incompleteness of the cortical afferents of the IV. cortical shell – this fact was determined in the course of the same exploration – can result in the compensatory extraordinary development of thalamic afferents in it which can cause different versions of the tonic pathology: spastic rigidity, rigidity, hyperkineses. A direct connection was discovered between a degree of development defect affecting the IV. shell of the premotor cortex together with the subsequent excrescence of the thalamic afferents in it, on the one hand, and severity of motor disturbance, on the other hand, with patients suffering from infantile cerebral palsy.

Comparing these data to the above-mentioned results of our survey one can assume that the DPC method contributes to elimination of pathological muscular synergies by means of normalizing the vestibuloproprioceptive flow and corrects such cortical mechanisms that regulate movements.

On the basis of the new biomechanical ratio of the body parts there appears a new "afferent framework" which, in its turn, exerts normalizing influence on the activity of antigravity structures as well, according to the principle of feedback, including activity of the nuclei of the reticular formation of the trunk and midbrain. At the same time, to judge from the findings of the electroencephalography and the observed data with respect to the somatosensory evoked potentials, activity of the ascending reticular formation and its thalamic nuclei is normalized one way or another too. This is confirmed by the fact that the bioelectrical activity is restored to a considerable extent in both hemispheres simultaneously under the direct effect of the "Adeli-92" treatment suit. Increasing more and more, the cortical control over the subcortical structures and the structures of the trunk is ensured in this way.

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