Treatment of Nervous and Mental Diseases

CHANGE OF INDIVIDUAL PROFILE OF INTERHEMISPHERAL CEREBRAL ASYMMETRY IN PATIENTS WITH SPASTIC FORM OF INFANTILE CEREBRAL PARALYSIS WEARING SPACE LOADING SUIT (ВЛИЯНИЕ КОСМИЧЕСКОГО НАГРУЗОЧНОГО КОСТЮМА НА МЕЖПОЛУШАРНУЮ АСИММЕТРИЮ МОЗГА ПРИ СПАСТИЧЕСКОЙ ФОРМЕ ДЕТСКОГО ЦЕРЕБРАЛЬНОГО ПАРАЛИЧА)

A.B.YAVORSKY, E.G.SOLOGUBOV, V.I.KOBRIN, A.N.SINELNIKOVA, S.A.NEMKOVA

Children's Psychoneuralogical Hospital No. 18, Russia's State Medical University, Moscow

The paper presents the study concerning influence of somatosensory stimulation (single wearing of either Penguin space loading suit or its modification – Adeli Suit) on the individual profile of interhemispheral cerebral asymmetry (IPIHCA) in patients with spastic form of infantile cerebral paralysis (ICP). The computer stabilograph analyzed motor arms' asymmetry, sensory asymmetry of visual hemiareas, asymmetry of the position of center of gravity. It is shown that peculiarities of the realization of the standing position either with visual control or without it both in healthy individuals and in patients depended on initial individual profile of interhemispheral cerebral asymmetry. Initial stability was higher in healthy individuals than in patients, besides in healthy persons it was higher in right handers while in patients – in left-handers. There was possibility of changes of both individual profile of hemispheral cerebral asymmetry and stability during keeping up vertical position even during single somatosensory stimulation. For elaboration of new criteria of the estimation of the efficiency of treatment in patients with damages of central nervous system, including infantile cerebral paralysis, it is necessary to take into consideration different influence of somatosensory stimulation on individual profile of hemispheral cerebral asymmetry in right-handers and left-handers.

Keeping up vertical position is a complex coordinative act in which many systems take part [4]. In the case of some neurological diseases this posture effect can be disturbed, in particular in patients with infantile cerebral paralysis. In our previous works [7, 8] it was shown that in patients with infantile cerebral paralysis stability was decreased during keeping up vertical position, and dynamic proprioceptive correction carried out by means of the "Penguin" space loading suit and its "Adélie" modification contributed to the correction of the position of body center of gravity and the normalization of the standing position in such patients. To all appearances, in the course of treatment of patients with infantile cerebral paralysis using this new method there is possibility of both reorganization of nervous linkage in cerebral hemispheres and changes of interhemispheral interrelations. Exploration of the possibility of changes of individual profile of interhemispheral cerebral asymmetry in patients with infantile cerebral paralysis could give theoretic substantiation to one of the mechanisms of action of this new treatment mode.

The study involved both 18 patients with spastic form of infantile cerebral paralysis at the age of 8-20 (their average age was 12.5 years) and 13 healthy children aged 13-15 (their average age was 13.1 years). Taking into account their initial motor asymmetry of arms determined with the use of the paper form method which was worked out by N. N. Bragina and T. A. Dobrokhotova, these groups was divided into two subgroups – left-handers and right-handers. Individual profile of interhemispheral cerebral asymmetry was based on motor asymmetry of arms, asymmetry of visual hemiareas, and asymmetry of extensor muscular tonus of both left and right half of body which was indirectly reflected in the position of body center of gravity.

We worked out computer research methods in respect of motor asymmetry of arms on the basis of a standard paper form test of lineograms [6]. Coincidence of movement direction of a computer mouse and its cursor – arrow on the display screen is the basis of it. This technique allows to determine precision and velocity of both a left and a right hand moving in four directions. The task of a person under test was to move a mouse with his left or right hand in such a way that its cursor could move as precise and quick as possible on the monitor screen along an imaginative line which passed through control points placed so that being connected they resulted in a broken trajectory. A person under test was suggested to move a mouse with his left or right hand from the

right to the left, from the left to the right, from the front backwards, and from behind forwards. After that, the area between both trajectories obtained by an examinee for each direction and an ideal computer trajectory was calculated with the use of a special computer program. With application of the inverse proportioning method a precision amount was calculated with respect to each direction, and, then, a summary precision amount was ascertained with respect to each direction for each hand. A hand with a higher precision amount was designated as a leading one. The present technique was standardized on the basis of a paper form test of lineograms for 11 adult persons (aged 19.7 on average), 7 of them were right-handers and 4 of then – left-handers. A high degree of correlation (0.96) was obtained between a standard paper form test and its computer realization.

To study sensory visual asymmetry a standard tachystoscopic technique was applied in computer adaptation [9]. The angular distance from a fixed point to the internal picture front constituted 7º, the stimulus duration was equal to 120 ms. Domination of one of the visual hemiareas become a criterion of assessment of the asymmetry at identification of a standard verbal stimulus – some letters of the alphabet among the others (or noise).

In order to assess a state of functional visual asymmetries and motor asymmetry of arms a standard formula of calculation of an asymmetry coefficient was applied *K*a [5]: $(R - L)/(R + L)$, where R and L are indexes of sensory or motor asymmetry on the right or on the left respectively. Positive value of a coefficient points to right-side asymmetry and negative value points to left-side asymmetry. A value near close to zero testifies to functional equality of the sides – ambidexterity.

We used stabilographic techniques which allow to bring out both oscillations of a body center of gravity in frontal and sagittal planes while an examinee is standing under Romberg's test and a position of center of gravity indirectly reflecting a contralateral extensor muscular tonus in the whole body. We assessed an average deflection of body center of gravity in frontal plane which deflection reflects a state of extensor muscular tonus in right and left halves of a torso and a leg, and also as a criterion of stability of examinees – the length and the area of a statokinesigram – a trajectory of a shift of center of gravity projected on the horizontal plane of a stabilograph Fig. 1). All the parameters were assessed during standing with open and closed eyes, and such an approach allowed to determine a role of visual analyzer in the control of stability during keeping up vertical position.

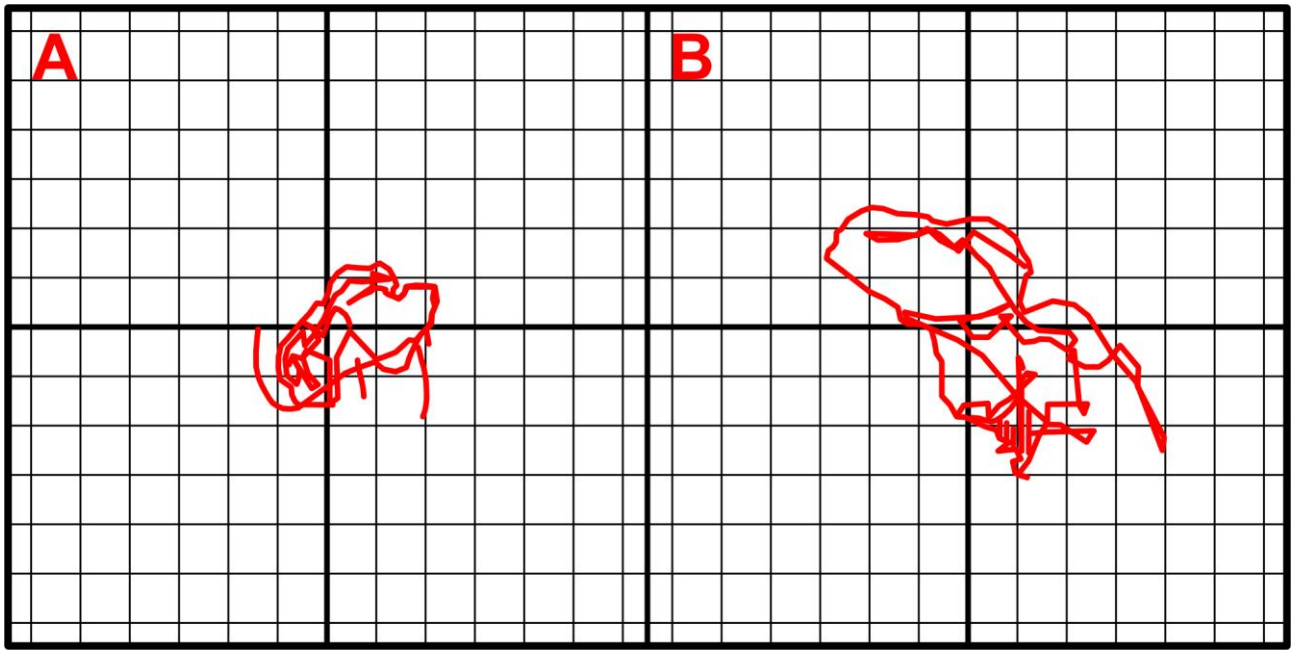


Fig. 1. Statokinesigram of a patient with spastic form of infantile cerebral paralysis during standing with (**A**) or without (**B**) eye control.

The somatosensory stimulation consists in the single 45-minute-long wearing of a Penguin space loading suit or its modification – Adeli Suit [1, 2]. Therefore, the study of both individual profile of

interhemispheral cerebral asymmetry and stability during keeping up vertical position was carried out immediately before the single wearing of a loading suit, during wearing and immediately after that. Techniques of Mann-Whitney distribution-free statistics were used for statistic data processing.

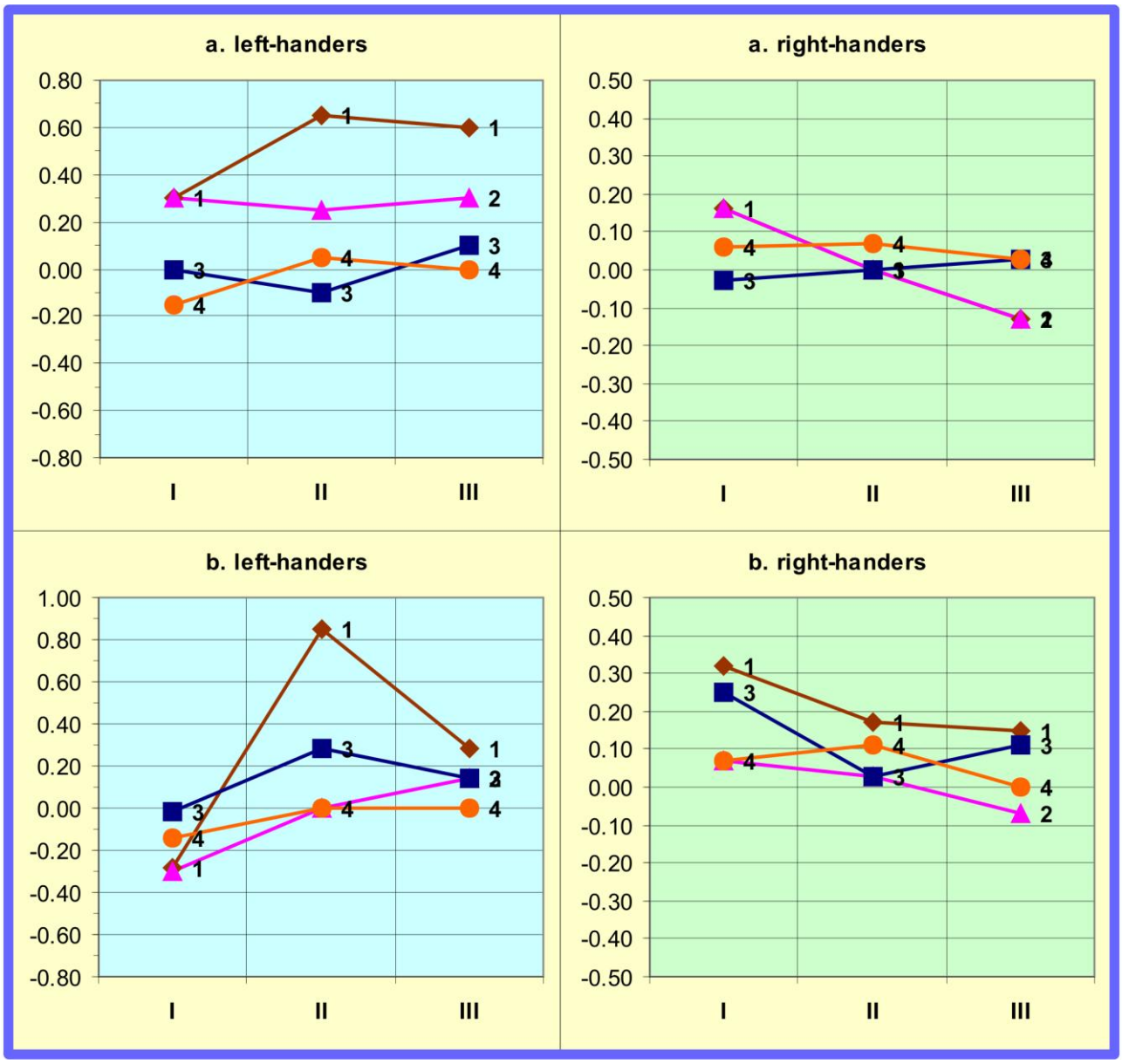


Fig. 2. Change charts in respect of both body center of gravity and coefficients of asymmetry (along the Y-axis) at somatosensory stimulation in healthy children (a) and in patients with infantile cerebral paralysis (b).

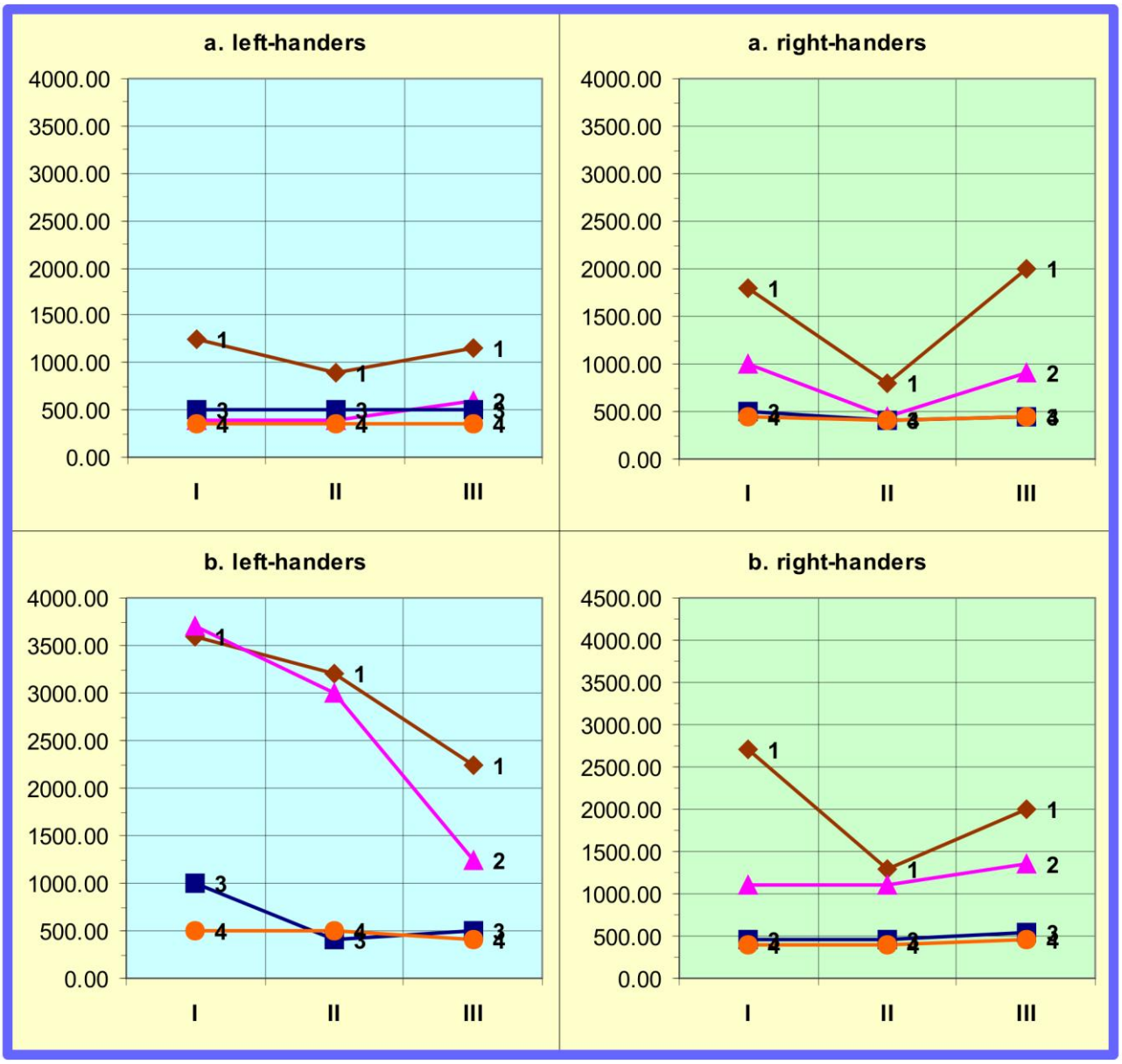
1 – shift of center of gravity during standing without eye control; 2 – with eye control; 3 – coefficient of visual asymmetry; 4 – coefficient of motor asymmetry of arms.

Here and in Fig. 3: I – before wearing a loading suit; II – during wearing; III – after wearing.

Healthy children. Before somatosensory stimulation a positive value of a coefficient of motor arms' asymmetry and a negative value of a coefficient of visual asymmetry came to light in right-handers – all this points to their right motor asymmetry of arms and the left visual asymmetry (Fig. 2.a).

During standing with or without eye control a right-side shift of center of gravity and a left-side predominance of extensor muscular tonus are observed in right-handers. In contrast to right-handers a negative coefficient of motor asymmetry of arms is revealed in left-handers. In fact there is no

visual asymmetry in them while a left-side extensor muscular tonus is predominant in right-handers, and presence or absence of eye control does not practically affect its distribution. Somatosensory stimulation leads to decrease of the initial motor asymmetry of arms in all healthy children. (see Fig. 2.a). Their visual asymmetry decreases as to initial values (in right-handers), but in left-handers a right-side visual asymmetry arises. Thus, somatosensory stimulation of a receptor apparatus of musculoskeletal system can result in change of the asymmetry of visual hemiareas. A single wearing of a loading suit decreases the initial muscular tonus in right-handers during standing with and without eye control. In left-handers a left-side extensor muscular tonus decreases during standing with eye control and increases without it. Measurements made during wearing a load-



ing suit bring out “evening-out” of initial asymmetries in all children except left-handers.

Fig. 3. Change charts in respect of the length and area of statokinesigram (in standard units) at somatosensory stimulation in healthy children (a) and in patients with infantile cerebral paralysis (b).

1 – area of statokinesigram during standing without eye control; 2 – with eye control; 3 – length of statokinesigram during standing without eye control; 4 – with eye control.

In respect of both left-handers and right-handers the length and the area of statokinesigrams are smaller during standing with eye control than during standing without eye control (Fig. 3.a). This fact confirms that a visual analyzer plays an essential role in control of keeping up vertical position

in healthy persons [4, 7, 9]. The length and the area of statokinesigrams are smaller in left-handers during standing both with and without eye control than in right-handers – this points to higher stability in left-handers. During and after somatosensory stimulation stability increases in all healthy children. The role of visual analyzer in control of keeping up vertical position increases in right-handers and decreases in left-handers.

Children with spastic form of infantile cerebral paralysis. Originally, the right motor asymmetry of arms in right-handed patients is comparable with such in healthy right-handers (Fig. 2.b). In them a considerable right visual asymmetry is revealed, a predominance of a left-side extensor muscular tonus is marked.

When conducting a control study, a negative value of a coefficient of motor asymmetry of arms shows itself in left-handed patients, this value is similar to the one determined in healthy children (Fig. 2.b). The comparison of such parameters in both right-handers and left-handers indicates that there is no influence of infantile cerebral paralysis on a degree of initial domination of arms. Apparently, in the case of spastic form of infantile cerebral paralysis both cerebral hemispheres, on the other hand, and symmetrical trunk structures, on the other hand, suffer in equal degree. In children of this group the left-side visual asymmetry is observed which is similar to visual asymmetry in healthy left-handers. When analyzing the results of Romberg's test, the right-side predominance of muscular tonus is revealed initially in left-handed patients. And this is exactly opposite to right-handers. Presence or absence of the eye control does not practically affect the muscular tonus as is in right-handers as well.

As a result of somatosensory stimulation, the initial motor asymmetry of arms and such visual asymmetry decrease in both right-handers and left-handers (see Fig. 2.b). Besides, the right-side predominance of extensor muscular tonus decreases in them during standing with or without eye control as well. In right-handed patients with infantile cerebral paralysis wearing a loading suit grouping of all parameters is revealed – which fact points to "evening-out" of asymmetries, though in smaller measure than in healthy children. There is no "evening-out" in left-handers whether healthy or not.

In patients with infantile cerebral paralysis the initial stability is worse than in healthy persons under test. In the group of the patients the stability during keeping up vertical position and the role of visual analyzer in its control are lower in left-handers than in right-handers (Fig. 3.b).

To all appearances, this is connected with the fact that it is mechanisms of control of stability during keeping up vertical position that suffer in left-handers in larger measure than elsewhere. As is well known, in the case of the majority of individuals (mainly with right functional asymmetries), somatotopic projection of a body and its scheme are localized in the right hemisphere. There may be space control disorders seen on mechanisms of stability in left-handers. After somatosensory stimulation this stability decreases to some extent in right-handed patients with spastic diplegia, and, on the contrary, increases essentially in left-handers, and a role of visual analyzer in control of standing position does not change in left-handers while it reduces in right-handers. Apparently, in spite of initially low stability, regulatory systems ensuring stability during keeping up vertical position are more plastic in left-handed patients with spastic diplegia if compared with right-handers and are able to restructure quickly under modulatory effect.

Collation of patients with spastic form of infantile cerebral paralysis and healthy children shows that the disease does not affect the state of initial motor asymmetry of arms: it is comparable in healthy individuals and in patients, and this fact may be conditioned upon lesion diffusivity in the case of infantile cerebral paralysis. The asymmetry of extensor muscular tonus during standing with visual eye control and without it is such in right-handed patients as in healthy right-handers, and in left-handers – exactly opposite. On the other hand, a spastic form of infantile cerebral paralysis does not result in any change in the control effected by visual analyzer in respect of distribution of muscular tonus during keeping up vertical position. One may deduce a conclusion from the facts above that in right-handers a disease does not change initial state of motor asymmetries, perhaps, because of sufficient symmetricity and diffusivity of lesion. At the same time, in left-handed individuals whether healthy or not there is difference between them in initial extensor muscular tonus. It is typ-

ical that in comparison with right-handers the stability in healthy left-handers is higher and in left-handed patients – lower. This can also testify to a stronger disturbance of mechanisms of stability in left-handed patients with spastic form of infantile cerebral paralysis. At somatosensory stimulation more essential growth of stability during keeping up vertical position is observed in left-handers whether healthy or not, than in right-handers, and this fact may point to more plasticity of regulating mechanisms of keeping up vertical position in left-handers. At the same time change of the role of eye control of stability in patients in Romberg's position is exactly opposite to such in healthy persons who were examined. This points to differences in organization of eye control of keeping up vertical position in healthy persons, on the one hand, and in patients, on the other.

Thus, individual profile of interhemispheral cerebral asymmetry is different both in healthy children and in patients with spastic form of infantile cerebral paralysis. Even a single wearing of a loading suit changes it in patients as well as in healthy persons. Stability during standing is higher in healthy left-handers than in healthy right-handers. In the case of spastic diplegia the indexes are exactly opposite, but in left-handed patients they are corrected better by somatosensory stimulation. These differences are to be taken into account when giving a course of treatment and working out criterions of the estimation of its effectiveness in patients with damages of central nervous system, in particular with infantile cerebral paralysis.

LITERATURE:

1. Barer A. S. Abstracts of a report at the 24th International Aerospace Congress. Baku, 1973; 40–43.
2. Barer A. S., Semyonova K. A., Sologubov E. G. et al. Neurology Bulletin (Nebrologichesky vestnik). Kazan, 1994; 26: 1–2, 26–31.
3. Bragina N.N., Dobrokhotova T.A. Functional asymmetries in an individual. Moscow: Meditsina, 1988.
4. Gurfinkel V.S., Kots Y.M., Shik M.L. Regulation of posture in an individual. Moscow: Nauka, 1965.
5. Dobrokhotova T.A., Bragina N.N. Psychopathology of focal brain damages. Moscow: Meditsina, 1977.
6. Ilyuchenok R.Y., Ilyuchenok I.R., Filkenberg A.L. et al. Interaction of cerebral hemispheres in an individual: establishment, information processing, memory. Novosibirsk: Nauka, 1989.
7. Sologubov E.G., Kobrin V.I., Yavorsky A.B., Bosykh V.G. et al. Aerospace and environment medicine. Moscow, 1995; 29: 5: 30–34.
8. Sologubov E.G., Kobrin V.I., Yavorsky A.B. Aerospace and environment medicine. Moscow, 1996; 6: 12–14.
9. Yavorsky A.B. Collection of works of a conference of Sechenov MMA "Contemporary problems of experimental and applied physiology". Moscow, 1993; 135-136.