THE ROLE OF VESTIBULAR AND VISUAL ANALYZERS IN CHANGE OF POSTURAL ACTIVITY IN PATIENTS WITH INFANTILE CEREBRAL PARALYSIS DURING TREATMENT WITH APPLICATION OF SPACE TECHNOLOGY (РОЛЬ ВЕСТИБУЛЯРНОГО И ЗРИТЕЛЬНОГО АНАЛИЗАТОРОВ В ИЗМЕНЕНИИ ПОЗНОЙ АКТИВНОСТИ У БОЛЬНЫХ ДЕТСКИМ ЦЕРЕБРАЛЬНЫМ ПАРАЛИЧОМ В ПРОЦЕССЕ ЛЕЧЕНИЯ С ИСПОЛЬЗОВАНИЕМ КОСМИЧЕСКОЙ ТЕХНОЛОГИИ) (Stabilographic Study)

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The article presents the findings of the stabilographic examination of children with hyperkinetic form of infantile cerebral paralysis treated with application of the method of dosated wearing of the Adeli Suit. The latter is a modification of the Penguin space suit, it is used to prevent unfavorable impacts of weightlessness on the skeletal musculature and the skeleton in protracted space flights.

The state of 30 children was examined before the course of treatment with application of the Adeli Suit as well as after that. Except patients, a control group consisting of 11 healthy volunteers. The examination included simple stabilometry, Romberg's test, and tests with head rotations.

The findings testify to the fact that a visual analyzer is of leading importance during keeping up vertical position in healthy persons. The eye control carried out by a visual analyzer decreases considerably in patients with infantile cerebral paralysis. The application of the Adeli Suit leads to enhancement of the role of a visual analyzer in control of the realization of the standing position. After a course of treatment with application of the Adeli Suit stabilimetric indexes improve in patients and approximate to the indexes characteristic of healthy persons.

It is known that the standing position of a person is his postural reaction. It is possible to keep up equilibrium if a projection of body center of gravity falls on the bearing area occupied with his feet [3]. In standing position certain permanent slight oscillations of the body center of gravity go on in healthy persons in frontal and sagittal planes. The cause of such oscillations consists, on the one hand, in respiratory movements, blood circulation and, on the other hand, in a functional state of the central nervous system and receptor apparatus which control motor musculature. The realization of the standing position may be regarded as a solution of the minimization problem in respect of a value of deflection of the body center of gravity from the equilibrium position [3]. Since there are many degrees of freedom in such a multicomponent system as is a body it is obvious that keeping up equilibrium is a complicated regulatory problem.

In hyperkinesis of different etiology the problem of keeping up equilibrium becomes even more complicated, as there can be asymmetry of hyperkineses and undue fatigability because of a substantial volume of superfluous motor reactions. As is well known, the fatigability sharply augments the amplitude of a shift of body center of gravity [3]. It can be believed that a decrease of intensity of hyperkineses of motor musculature may result in the stabilization of body center of gravity and the growth of stability.

The infantile cerebral paralysis of various forms including hyperkinesis is one of the most frequent diseases entailing a change in motor sphere. Formerly, we have shown a significant therapeutic effect in patients with infantile cerebral paralysis during applying the Adeli treatment suit which is a modification of the Penguin suit, used to prevent unfavorable impacts of weightlessness on the skeletal musculature and the skeleton in protracted space flights [1, 2]. At the same time partial normalization of the function of vestibular system was recorded, and a degree of the recovery of the function of vestibular system was correlated to some extent with the effectiveness of the treatment. It is also known that a visual analyzer is of a great importance in the realization of the standing position [3]. The present paper continues the study commenced before and demonstrates additional possibilities to examine some pathophysiological effects accompanying the treatment of patients with application of Adeli Suit.

Technique

Two groups of volunteers were examined. The control group consisted of 11 healthy persons of both sexes at the age of 18-19. In respect of all examinees of the patient population (30 persons of both sexes at the age of 9-12) the diagnosis of infantile cerebral paralysis, hyperkinetic form of the disease or hyperkinetic syndrome, was made. In the greater part of the patients the state of moderate and grave severity was established. In 40 percent of the examinees the eyesight was reduced 10-90 percent.

The examination was carried out on a stabilographic complex of CT-002 consisting of stabilographic platform, digital device, computer of IBM PC/AT386 type with software.

Analyzing the results the following parameters were estimated: initial deflection along the X-axis (in sagittal plane), initial deflection along the Y-axis (in frontal plane), root-mean-square in both frontal and sagittal planes, length of the curve of a statokinesigram which is a projection of the shift of the body center of gravity on horizontal plane, area of the statokinesigram.

In the work the following tests were applied:

1) the usual stabilography when a examinee stands on the stabilographic platform during 20 seconds;

2) Romberg's test when an examinee stands on the stabilographic platform with open eyes (during 20 seconds) and, then, with closed eyes (during 20 seconds);

3) a test when both findings are compared; for this purpose two stabiliograpgic examinations are made in consecutive order (20 measurements each), and after that a computerized data processing and comparison of the findings followed;

4) a test with head rotations which was as follows: a patient stood on the platform at first with open eyes (background) and then with closed eyes, after that he rotated his head once to the left and once to the right with closed eyes. Each procedure lasted for 20 seconds. On the basis of the findings an average position of the body center of gravity is established for each state which is expressed by a coefficient of asymmetry, as well as an angle and a length of the displacement vector of a point of initial deflection with regard to the background.

The stabilographic examination was carried out in respect of both healthy persons and patients whom it was prescribed a dosated wearing of the Adeli Suit. A course of wearing a suit consisted of 20 runs, one wearing a day. The duration of a wearing grew gradually from 15 minutes to 1.5 hour. The examinee was subjected to the stabilographic examination before wearing a suit, at the beginning of the course and by the end of it. A number of patients went through a course of stabilographic examination in 3, 5, 10 days after the beginning of wearing a suit. With a view to statistically process the data a set of standard programs was applied.

Findings and discussion

Analyzing the findings of stabilography in healthy persons it was revealed that the length of the appropriate statokinesigram with both open and closed eyes is not large, but the statokinesigram is approximately 1.5 times shorter in the first case than in the second one (Table 1). The area of the displacement of body center of gravity takes a small value with both open and closed eyes, but it is 2.5 times smaller with open eyes than with closed eyes. In healthy examinees the position of the body center of gravity differs insignificantly during standing either with open or with closed eyes. In fact, such body centers of gravity coincide and are approximated to the common center of the coordinate system. During standing with open and closed eyes the differences in healthy examinees are statistically significant ($p<0.05$) in all respects. This confirms the fact that in healthy persons a visual analyzer is of essential importance in control of the position of the body center of gravity.

The measurement data that are relative to the statokinesigram of one of the patients before and after wearing a suit and after mathematical processing of the data are shown in Table 2.

Before wearing a suit the length of the statokinesigram with open and closed eyes and the area of displacement of the body center of gravity with open and closed eyes were larger in patients in comparison with the healthy examinees; the value of the ratio of the area of displacement of the

body center of gravity to the length of the curve reached tenfold and more. Swift, sharp movements with high amplitude of the body center of gravity were revealed in the patient. There was recorded a considerable difference when standing in Romberg's test with open eyes and with closed eyes. Thus, the area of the statokinesigram was larger when standing with closed eyes than when standing with open eyes (in some examinees the difference was threefold and more), the length of the curve become 1.5-3 times longer, and the ratio of the area of a displacement of the body center of gravity to the length of the curve increased. The amplitude of movements was large, and the movements were sharper – the fact that testifies to an increase of velocity and an acceleration of displacement of the body center of gravity; in this connection some patients lost their balance with closed eyes.

Besides, certain difference between the average position of the body center of gravity with open eyes and the average position of the body center of gravity with closed characterized the present group of patients too. As a rule, the average position of the body center of gravity with open eyes was more lateralized to the right, and with closed eyes – to the left. Several examinees had an opposite laterality with open and closed eyes. A degree of laterality was estimated on the basis of the initial deflection along the Y-axis. Positive values in view of these indexes pointed to a larger displacement of the body center of gravity to the right, and negative values – to the left. The values near close to zero confirmed the absence of lateralization (Table 2).

In the tests with head rotations a degree of lateralization of the body center of gravity was more evident. It may be connected with the corticosubcortical mechanism exerting an inhibitory effect on the segmental apparatus of the spinal marrow and preventing the formation of pathological reflexes [4], including tonic cervical reflexes [5]. The head rotated to the left or to the right, a displacement of the body center of gravity occurred in several examinees, so the laterality of muscular tonus was subject to the side affected. Thus, one may suppose that in persons with hyperkinetic syndrome a control of standing position is conducted with less evident participation of the visual analyzer.

In patients with hyperkinetic form of the disease after wearing a suit for the 5^{th} – 10^{th} time a gradual disappearance of the difference between the average position of the body center of gravity when standing with open eyes and the average position of the body center of gravity when standing with closed eyes was observed, and, besides, a displacement of the body center of gravity from the common center of the coordinate system in frontal and sagittal planes decreased. At the same time, in the 5^{th} – 10^{th} day of the wearing of a suit a strengthening of hyperkineses was recorded when standing both with open and with closed eyes, but the ratio of the area of the curve and its length (when the eyes are open) to appropriate indexes (when the eyes are closed) approaches one gradually, – the fact that testifies to the disappearance of a difference between standing with open eyes and standing with closed eyes. The temporary strengthening of hyperkineses may be connected with "shocking" habitual stereotypes of the motor behavior formed in the course of the whole life of a person. In a number of examinees (7 persons) such "shocked" state remained till the day of discharge. By the 20^{th} day of the wearing of a suit the indices if compared with the initial ones changed for the better in the majority of the patients with hyperkineses. However, the heterogeneity of the patient population in view of a degree of severity of the disease does not allow to discuss here any evident statistic significance.

After 20 days of the wearing of a suit most of the patients with infantile cerebral paralysis – their eyes being open – can stand better than by the moment of the initial measurements. Nevertheless, in case the intermediate stabilographic investigation is carried out in some patients an increase of the area of statokinesigram is recorded in the 5^{th}–10^{th} day of the wearing of a suit. It is obvious that the motor stereotype in these examinees – their eyes being open – is more labile and is more subject to modulations than in case their eyes are closed, that is why it is more amenable to correction. In some patients such changes do not succeed to take shape by the 20^{th} day of the wearing of a suit and are revealed in the course of a repeated cycle of the wearing a suit after a two-month recess. In them the position of the body center of gravity changes both with open and with closed eyes.

After a course of treatment with application of a loading suit the indices of root-mean-square deviation both in frontal and in sagittal planes change while the body center of gravity of the examinee approximates to the center of the coordinate system (Table 3), and the difference between two positions of the body center of gravity (on the one hand, with open eyes, and, on the other, with closed eyes) smoothes down.

The stabilographic findings obtained during follow-up two months after a single course of application a loading suit reaffirm the existing improvement. In a number of cases these findings point to the fact that the formation of a new motor stereotype continues after a single course of application of a suit. 1-2 months after wearing a suit a difference between the average positions of the body center of gravity either with open or with closed eyes comes to light during Romberg's test which may be connected with a lateralization again appearing during standing with closed eyes.

Thus, the findings testify to the fact that in healthy persons the visual analyzer plays the chief role in the realization of the standing posture. In patients with hyperkinetic form of infantile cerebral paralysis the realization of the standing posture is accompanied with a considerable decrease of the control conducted by the visual analyzer. The application of the Adeli loading suit results in an increase of the role of the visual analyzer in a control of the realization of the standing posture.

Table1. Finding of stabilographic examination in respect of healthy persons (*n* = 11)

Parameters, mm							
LIO	**LI**	**TAO**	**TA**	**AyO**	**Ay**	**AxO**	**Ax**
276	482	460	1119	3,26	4,97	4,35	6,44
±20,9	±36,6	±88,07	±166,9	±0,39	±0,47	±0,73	±0,57
(159-378)	(357-966)	(128-966)	(585-2314)	(1,53-5,26)	(2,96-7,31)	(1,9-10,24)	(3,83-9,84

Note: In brackets minimum and maximum values are shown. LIO – length of statokinesigram with open eyes, LI – length of statokinesigram with closed eyes, TAO – area of statokinesigram with open eyes, TA – area of statokinesigram with closed eyes, AyO – root-mean-square deviation in frontal plane with open eyes, Ay – root-mean-square deviation in frontal plane with closed eyes, AxO – root-mean-square deviation in sagittal plane with open eyes, Ax – root-mean-square deviation in sagittal plane with closed eyes.

Table 2. Findings of stabilographic examination in respect of a patient C. before (the upper line) and 20 days after a course of application of a loading suit (the lower line)

Parameters, mm											
LIO	**LI**	**TAO**	**TA**	**AyO**	**Ay**	**AxO**	**Ax**	**y**	**yo**	**X**	**xO**
1070	2909	3867	19821	8,59	14,41	8,37	15,87	4,24	0,35	4,76	3,53
742	1489	2014	3989	7,29	8,89	6,34	8,89	3,91	-2,33	3,4	-0,88

Note: Designations as in Table 1. Besides, xO – initial deviation in sagittal plane with open eyes, yO – initial deviation in frontal plane with open eyes, x – initinal deviation in sagittal plane with closed eyes, y – initial deviation in frontal plane with closed eyes.

Table 3. Findings of stabilographic examination in respect of all the patients (30 persons) before application of a suit (the upper line) and after that (the lower line)

Parameters, mm							
LIO	**LI**	**TAO**	**TA**	**AyO**	**Ay**	**AxO**	**Ax**
1047	1343	5237	7587	10,11	13,1	9,69	11,25
±124,76 .	±160,88	±920,31	±1214,08	±0,7	±1,27	±0,9	±0,76
(297-2624)	(327-3858)	(546-20831)	(719-28263)	(3,38-17,51)	(4,89-0,3)	(4,31-24,08)	(5,52-24,79)
977	1331	4569	8058	9,48	11,5	8,86	11,89
±121,9	±168,78	±822,56	±1782,68	±0,75	±1,04	±0,72	±1,1
(270-3535)	(346-4390)	(273-20970)	(512-42580)	(2,42-19,24)	(2,47-27,18)	(2,37-18,20)	(3,62-26,68)

Note: In brackets minimum and maximum values are shown. Abbreviation as in Table 1.

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