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A New Method for Rehabilitation of Patients after a TIA with the Use of an Interactive Stand

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Abstract: Each case of rehabilitation of patients with central paresis of the upper extremity requires a multidisciplinary approach from specialists based on the needs of the patient and depending on a number of other circumstances.

The article presents a review of specially developed modern methods used for rehabilitation of the upper extremities after acute cerebral circulatory disorders. Conclusions and research findings on the organisation of rehabilitation in the home are shown.

The paper presents the results of using a complex interactive stand developed at Belgorod State University for the rehabilitation of patients with OHIM. Data on the usefulness of the developmental stand in the process of motor rehabilitation are formulated.

Keywords: stroke, developmental bench, motor rehabilitation, upper monoparesis, central paresis, neurorehabilitation, outcome evaluation.

Introduction

Acute cerebral haemorrhage (ACB) is one of the most serious and widespread health problems in the world today. CABG is one of the most common causes of death and disability in the adult population.

The risk of stroke increases with age: it is estimated that up to 75% of stroke survivors were over the age of 65 (InternetStrokeCenter, 2016).

There are many successful developments in the treatment of the acute period of stroke, but despite this many people remain disabled after suffering a stroke. Therefore, the search for effective rehabilitation methods for patients continues.

Motor disturbances in the limb in the form of central paresis are a common consequence of a CNS. These occur when CNS structures are affected at the level of the cortical motoneuron or the cortico-spinal conduction pathway. Clinically, this is expressed as a combination of positive symptoms (spasticity, deep hyperreflexia, the appearance of pathological reflexes and clonus, pathological synergies) and negative symptoms (muscle weakness, decreased dexterity, level of movement control).

Rehabilitation of patients with central paresis of the upper extremity is a very complex process, often requiring an individualised approach from specialists depending on the needs of the patient, the severity of the underlying pathology, the presence of comorbidities and many other circumstances.

The main objectives of rehabilitation are to restore lost limb function, treat secondary pathological syndromes and prevent recurrent strokes (Shishkova, 2016). Rehabilitation interventions are most effective during the first 6 months after emergence from the acute phase of the disease (early recovery period), after which (in the late recovery and residual periods) recovery options are significantly limited (Intercollegiate Stroke Working Party, 2012).

Today, there is a system of staged rehabilitation of patients after a UTI based on the integration of inpatient and outpatient stages, corresponding to 3 levels of rehabilitation: recovery, compensation and re-adaptation. In this system, an early start of rehabilitation measures, continuity of treatment, an integrated approach with simultaneous use of different types of rehabilitation therapy (medication, physiotherapy, occupational therapy, psychotherapy, etc.), as well as active participation in the recovery process by the patient and the help of relatives are very important (Borisov, Markin, 2007).

Based on a detailed analysis of modern interactive installations, the team of authors developed and applied in the rehabilitation process a functional board of the Bisibord type. Its elements are designed to restore the basic functions of the upper extremity to meet the patient's everyday needs. In this article we will evaluate the effectiveness of this device on the basis of data obtained during a rehabilitation course in 30 patients.

A brief description of the rehabilitation method used

The Bisiboard is a rehabilitation tool that uses the mechanotherapy method as its basis. Limitation of mobility of the upper extremities after a stroke significantly impairs the quality of life, since most daily activities involve hand movements in one way or another. In order to improve motor function recovery, intensive training is needed to restore or maintain the functional ability needed to perform everyday activities. Many training exercises involve manipulating real everyday objects under the supervision of a specialist (Woldag, Hummelsheim, 2002). Bilateral hand training is particularly effective (Wu, etc. , 2019). When both hands perform the same movement, the activity of the affected hemisphere of the brain increases, using the activity of the unaffected hemisphere as a template, resulting in clearer and faster movements of the affected hand.

Rehabilitation for patients after a UTI is mostly carried out in specially equipped centres under the supervision of specialists. However, many international researchers have noted that rehabilitation programmes are more effective in the home.

The analyzed "Bisibord" uses elements which are real industrial products: a bolt, a furniture lock with a key, a switch, a socket, a plug. There are also devices for simulating lacing and tying various knots, identical to those actually used in clothes and footwear. All this makes it as realistic as possible and best helps patients to learn the necessary self-care skills.

It also has elements that enable the development of fine motor skills and spatial orientation by selecting and sorting elements of different geometric shapes, by simulating a threaded joint (screw-nut).

In order to achieve practical significance of this tool, the methodology of lessons and elements of the board were repeatedly discussed with rehabilitation doctors of the Regional Vascular Centre of the Regional Clinical Hospital "St. Joasaph" and the Novo-Tavolzhanskaya Medical Rehabilitation Hospital. As a result of testing several prototypes, the authors created a layout most suitable for rehabilitation of patients with different types of upper limb motor disorders. An optimal set of exercises was also developed to work most effectively with this functional device.

Rehabilitation of 30 patients (10 women and 20 men) of mature and elderly age with varying degrees of ONMA, who had previously undergone inpatient treatment at the Novo-Tavolzhskaya Medical Rehabilitation Hospital in the Belgorod region, was carried out. All patients were given a 3-month rehabilitation course by medical volunteers using a developmental booth at home. Specially designed scales were used to standardize and evaluate the results obtained, such as: Six-point muscle strength assessment scale, Ashworth modified scale, upper limb central paresis (motor impairment) severity assessment, mobility assessment (by Rivermead), night sleep assessment, spasticity (muscle tone) assessment, cognitive impairment assessment, depression and anxiety level assessment, as well as the following methods of indicator measurement: BP, HR, height, weight, BMI and angiometry, dynamometry.

The information gathered during the rehabilitation process was standardised on scales and analysed using neural networks. The patients were divided into groups and the individual effects of rehabilitation on mobility were considered.

Indicators for upper limb mobility are the Ashforth scale, the central paresis severity scale, and angulometry of all joints of the upper limbs of patients.

Data analysis methodology:

Neural network cluster analysis was used to assign patients to groups. Statistica 10 software was used to handle the neural networks. The Kohonen 1000 algorithm was chosen as the neural network training algorithm, with a self-organising feature map (SOFM) architecture.

In order to test the quality of the rehabilitation package carried out, neural networks defined the data into 3 samples: a training sample, a test sample and a control sample. Each sample was used step by step. This resulted in a final quality assessment and a comparison of the indicators responsible for mobility before and after the rehabilitation period.

Table 1 shows the results of the initial examination of patients with different types of upper limb motor impairment.

The 30 patients were divided into 4 types (from worst to best results) based on the results of the neural network:

- The first type is shown in orange. These are patients with severe abnormalities in both angulometry and Ashforth's scales and assessment of the severity of central paresis of the upper limb.
- The second type is shown in yellow in the tables. This includes female and male patients with satisfactory angiometry scores and those with severe impairment on the scales.
- The third type is shown in blue. This includes male and female patients with severe scale abnormalities but with good angiometric scores.
- The fourth type is green. These are patients with slight abnormalities in all indicators.

At the end of the rehabilitation period, the results of all the indicators examined were recorded again. The final distribution of patients is shown in Table 2.

Table 1.

№	*Type*	*Age*	*Sex*	*EE*	*CCVP*	*Goniometry (in degrees)*									
						P BB	*P HH*	*L R*	*L S*	*W B*	*W BH*	*W L*	*W P*	*W Pp*	*SS*
№1	**1**	38	m	4	3	165	10	145	74	5	15	10	5	105	96
№2	**1**	49	w	3	3	160	70	130	130	40	30	18	21	45	53
№3	**2**	69	m	4	2	180	70	120	60	25	30	9	30	30	20
№4	**4**	74	m	2	5	140	70	170	130	70	65	35	40	85	70
№5	**1**	63	m	1	3	140	40	120	70	10	80	5	15	40	30
№6	**1**	58	m	4	3	60	20	160	10	0	15	5	4	0	10
№7	**1**	63	m	3	3	170	40	140	80	21	33	17	24	27	44
№8	**1**	71	m	4	4	79	45	160	140	11	44	28	10	60	11
№9	**1**	81	w	1	4	160	35	180	135	10	10	23	32	45	56
№10	**2**	80	w	3	4	175	60	110	60	55	45	25	28	26	30
№11	**4**	61	m	2	3	180	70	151	80	29	35	35	35	30	30
№12	**2**	65	w	4	1	157	20	100	40	35	30	30	28	29	29

№13	**1**	72	m	2	3	175	75	150	70	50	12	18	4	30	30
№14	**2**	80	w	3	3	156	60	110	60	33	7	25	25	30	29
№15	**2**	57	m	3	3	160	30	110	60	60	55	15	14	15	14
№16	**3**	64	w	4	1	180	60	110	70	75	70	45	30	30	30
№17	**2**	58	w	4	3	170	60	110	60	35	35	29	29	30	30
№18	**4**	49	m	3	0	135	40	180	80	30	25	30	30	60	90
№19	**4**	78	w	3	3	175	50	170	50	45	55	35	40	75	70
№20	**4**	58	m	2	3	180	70	175	60	60	35	35	40	80	75
№21	**1**	57	w	3	3	135	70	160	50	40	42	20	10	80	30
№22	**3**	68	m	3	2	165	65	140	70	55	40	30	30	70	40
№23	**3**	67	m	3	3	150	20	135	40	45	40	30	33	65	50
№24	**2**	56	m	3	4	160	60	110	40	40	35	25	30	60	51
№25	**3**	52	m	3	3	150	55	120	55	50	45	36	30	50	40
№26	**3**	72	w	3	3	165	80	110	90	70	40	30	40	50	45
№27	**3**	67	m	3	3	160	70	115	75	70	42	34	46	47	40
№28	**3**	64	m	3	1	135	45	125	60	50	35	30	40	40	35
№29	**2**	64	m	3	3	110	60	100	50	30	50	30	30	45	34
№30	**3**	64	m	4	2	140	55	120	55	40	45	45	43	44	40

The symbols used in the tables:
EE - Ashforth Scale score; CCVP - central paresis severity score; P BB - shoulder upward movement, P HH - shoulder downward movement; L R - extension at the elbow; L S - flexion at the elbow; WB - upward movement of the wrist; WBH - downward movement of the wrist; WL - leftward movement of the wrist; WP - rightward movement of the wrist; WPp - pronation of the wrist; SS - supination of the wrist

Table 2.

№	*Type*	*Age*	*Sex*	*EE*	*CCVP*	*Goniometry (in degrees)*									
						P BB	*P HH*	*L R*	*L S*	*WB*	*WBH*	*WL*	*WP*	*WPp*	*SS*
№1	**4**	38	m	4	3	165	75	165	85	25	90	25	20	130	165
№2	**4**	49	w	0	0	162	70	130	150	62	45	35	32	62	65
№3	**2**	69	m	4	2	180	100	140	65	30	60	25	10	50	55
№4	**4**	74	m	1	5	180	140	177	130	75	80	49	50	135	100
№5	**4**	63	m	1	2	165	75	143	105	78	84	33	65	87	68
№6	**1**	58	m	4	3	65	34	166	20	10	23	20	17	34	47

№7	**4**	63	m	3	3	180	66	150	80	55	58	34	53	44	54
№8	**4**	71	m	2	2	75	42	165	140	48	40	23	35	50	53
№9	**4**	81	w	1	4	175	56	180	167	20	28	40	45	55	75
№10	**3**	80	w	3	4	180	74	132	69	62	71	38	40	50	45
№11	**4**	61	m	1	2	180	79	167	88	37	57	39	42	68	53
№12	**3**	65	w	4	1	171	33	124	51	41	63	37	37	50	66
№13	**4**	72	m	2	3	180	80	166	80	64	44	24	19	72	67
№14	**3**	80	w	3	2	170	69	132	73	55	38	29	36	65	44
№15	**3**	57	m	3	3	172	42	130	89	80	64	27	34	43	58
№16	**3**	64	w	4	1	180	64	127	93	82	86	45	51	58	54
№17	**4**	58	w	3	2	176	69	142	87	57	59	38	43	67	65
№18	**4**	49	m	2	2	163	54	180	97	40	34	32	44	67	99
№19	**4**	78	w	2	2	177	58	175	74	54	63	41	42	84	87
№20	**4**	58	m	1	1	180	88	178	78	72	48	36	43	86	83
№21	**4**	57	w	2	2	175	80	160	70	50	50	40	30	80	75
№22	**4**	68	m	2	2	175	70	160	70	55	50	40	35	75	55
№23	**4**	67	m	3	3	175	60	160	60	50	60	43	40	70	55
№24	**4**	56	m	2	4	180	70	160	65	55	60	40	45	70	70
№25	**4**	52	m	2	2	170	65	160	65	50	65	45	45	70	50
№26	**4**	72	w	2	2	175	80	155	90	70	60	50	40	70	55
№27	**4**	67	m	2	2	170	75	150	80	75	65	45	50	65	50
№28	**4**	64	m	2	1	165	65	160	70	65	45	40	50	50	55
№29	**3**	64	m	2	2	150	70	140	60	60	55	40	45	55	45
№30	**4**	64	m	2	2	170	67	165	65	50	50	50	55	60	65

The symbols used in the tables:
EE - Ashforth Scale score; CCVP - central paresis severity score; P BB - shoulder upward movement, P HH - shoulder downward movement; L R - extension at the elbow; L S - flexion at the elbow; WB - upward movement

of the wrist; WBH - downward movement of the wrist; WL - leftward movement of the wrist; WP - rightward movement of the wrist; WPp - pronation of the wrist; SS - supination of the wrist.

We can see that, after rehabilitation, most of the patients improved significantly. There was no negative trend in any of the patients.

If you compare the trend data in more detail, you can divide all patients into 4 groups:

1) Patients with high gains on almost all indicators. They have progressed from Orange and Yellow to Green in the rehabilitation process. There are only 36% of them.

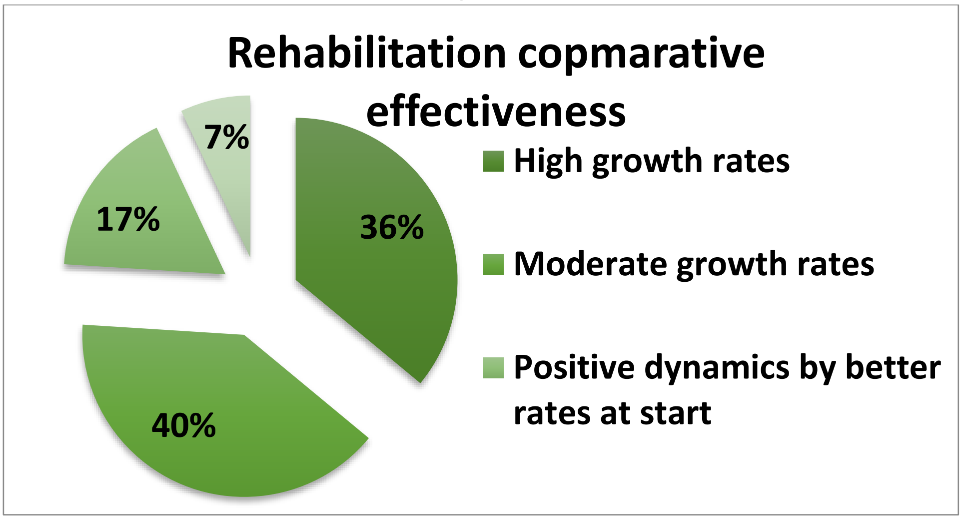
2) Patients with an average increase in most of the studied parameters. This group contains 40% of all patients.

3) Patients who were immediately classified as 'green'. All of these people have shown a positive trend over the rehabilitation period, but they were initially quite high, so the final increase does not seem to be that great. There are only 17% of these patients.

4) Patients who had only a small increase in the measures under investigation. There are only 7% of them and they were all rehabilitated with Bisibord more than 6 months after the AIS episode, which is probably the reason for its low effectiveness.

For the sake of clarity, we have presented this data in the form of a diagram below (Figure 1).

Figure 1.



Conclusions

The basis for most rehabilitation activities carried out at home are static units specifically aimed at developing compound movements, on which exercises are supervised by specialists. However, repetitive exercises on these machines are often monotonous, so interest in doing them decreases over time. Rehabilitation is also often a long process, which can make patients lose confidence in their recovery. All this leads to a decrease in motivation and compliance, which negatively affects the effectiveness of the therapy being carried out. Therefore, one of the challenges of creating an effective rehabilitation programme is to develop techniques and tools to keep patients interested in the exercises they do.

Based on a detailed analysis of modern interactive installations, the team of authors developed and applied in the rehabilitation process a functional board of the Bisibord type. Its elements are designed to restore the basic functions of the upper extremity to meet the patient's everyday needs. Information that has been given in the present paper, shown the effectiveness of this device on the basis of data obtained during a rehabilitation course in 30 patients.

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