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Physical Rehabilitation of Patients with Cerebral Blood Flow Acute Disorders in the Late Recovery Period

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Abstract

The purpose of this article is to substantiate, develop and evaluate the effectiveness of a physical rehabilitation comprehensive program using functional training method for patients with cerebral blood flow acute disorders in the late recovery period. The rehabilitation program focuses on improving the quality of life indicators according to the International Classification of Functioning, treating movement disorders and returning patients to their previous functional level. The ascertaining experiment involved 73 patients. The primary diagnosis was the consequences of cerebral blood flow acute disorders lasting for at least 6 months and not more than 9 months after a stroke. The physical rehabilitation comprehensive program was implemented amongst the patients of the experimental group (n=35) and the control group (n=38), the latter attending a standard physical rehabilitation course in a medical institution. The statistical analysis revealed a great number of correlations at a significant level, which is explained by the connection between body structures and functions, activity and participation. The study proves the effectiveness of the proposed program as compared to the traditional approaches. It ascertains that using specialized methods based on functional training in post-stroke rehabilitation programs is the way to increase functional capacity and improve the adaptation of stroke patients.

Keywords: *physical therapy, stroke, functional training, activity, participation*

Introduction

In Ukraine there are currently a number of projects on physical rehabilitation of stroke patients in the acute and early rehabilitation periods, for example, the Ukrainian Anti-Stroke Association, which clearly outlines protocols for providing rehabilitation assistance to stroke patients (Holik, 2011). However, despite some advances in the rehabilitation of stroke patients in the acute period, the problem of functional movement disorders rehabilitation in the late period remains poorly developed (Krupinski, Secades, & Shiraliyeva, 2013; Cifu, 2016). Standard programs based on traditional means and methods, including massages, combinations of therapeutic physical training, and physiotherapy are mostly used in the late period (Bohdanovska & Kalenova, 2017). Therefore, there are no programs for comprehensive recovery of physical, neuropsychiatric and linguistic spheres of stroke patients in the late period (Bilianskyi, Skobolyak, & Rokoshevska, 2018).

The strategy for solving this problem consists of reducing physical disabilities, increasing acquisition of new skills and abilities that maximize patient's activity, changing the environment to minimize social restraints (Braunet et al., 2013; Breceda & Dromerick, 2013). Using methodological approaches of

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the International Classification of Functioning (ICF) allows conducting a comprehensive analysis of the existing physical disabilities (Rokoshevska & Kruk, 2016; Dmytruk & Rokoshevska, 2017). Up-to-date rehabilitation interventions should be aimed at enhancing neuroplasticity processes to restore lost movement and cognitive functions (Cifu, 2016). The functional training method involves restoring and compensating for lost physical characteristics by training motor skills that are necessary to improve or return to normal social life (Kitago & Krakauer, 2013; Winstein et al., 2016).

Thus, it would be appropriate to develop and test new differentiated programs of physical rehabilitation of patients with cerebral blood flow acute disorders in the late recovery period based on the current approach of the ICF aimed at participation level.

Methods

Participants

The study involved 73 patients, eligible to take part therein, i.e. having clear consciousness with a level of wakefulness sufficient to withhold and execute instructions during exercises; having no severe somatic pathologies, acute systemic diseases, uncontrolled sinus tachycardia with a heart rate of more than 120 beats per minute, musculoskeletal disorders, which complicate exercising, lack of sensory aphasia and cognitive disorders that prevent active involvement of patients in rehabilitation activities.

All persons were informed about the content of the tests, measurement procedures and signed an informed consent form. The research was approved by the Institutional Ethics Committee (number 1/2017) and was carried out in compliance with the international principles of the Helsinki Declaration of the World Medical Association (World medical association Declaration of Helsinki, 2013), and following the Law of Ukraine "Fundamentals of Ukrainian Legislation on Healthcare" (Law of Ukraine, 1992) on ethical norms and rules for conducting medical research involving human.

Procedure

The study, conducted at the premises of the neurorehabilitation department of Kyiv City Clinical Hospital No. 8, was as follows:

Patients with the consequences of cerebral blood flow acute disorders lasting for more than 6 months after a stroke, who were at the neurorehabilitation department of the hospital, underwent an objective rehabilitation examination.

Prior to starting rehabilitation activities, a rehabilitation survey was conducted, which used ICF methodological approaches to solve the problems at the level of body functions and structures, activity and participation.

The patients were divided into 2 groups: the experimental group (EG), n=35 and the control group (CG), n=38. For the patients of the EG, a 27-week program was developed based on ICF methodological approach. The CG used the standard 27-week program of the institution which consisted of massages, a sequence of therapeutic exercises and ergocycling.

EG program included three periods of four weeks each with five weeks intervals between them.

The frequency of the classes per week was 5, 2 classes per day; each class lasted 45-60 minutes.

For detecting selective and optimal effects on improving patient's life quality, major disorders of body functions and systems were identified. The type of these disorders determined rehabilitation interventions by means of selecting physical exercises to perform various functional tasks that help patients to restore or compensate for the skills necessary for a normal life and active participation in public activities.

In each of the three rehabilitation periods, tasks were addressed at the level of disorders of structures and functions, activity and participation, but the correlation of the tasks was directly proportional to the patients' initial state. In the first period, patients had significant disorders at the function and structure level that influenced positive outcomes of attaining independence at the activity and participation level, and accordingly, more time was given to the exercises aimed at improving function and structures.

Closer to the end of the rehabilitation course, patient's movement tasks were aimed at achieving functional independence at the participation level.

The program was based on individual exercises with the patient to ensure independent, efficient and long-term movement in space, restore upper limb and hand functioning. Restoration of physical activity was closely related to restoration of the necessary components of mental activity, which is crucial for a productive life.

Each period of the physical rehabilitation program included tasks and exercises aimed to improve functional independence, but the distribution by ICF domain was different.

In the first rehabilitation period correlation of the exercises to solve problems at different levels was as follows: problems at the level of structures and functions – 50%, at the level of activity – 30%, at the level of participation – 20%. The problems at the level of structures and functions needed more time because of low functionality and rough disruptions of the structures that made it impossible to fully complete the tasks at the level of activity and participation. This period included: medical history analysis, examination, determination of the nature and degree of motor function disorder, determination of mental status, restoration of movement amplitude, exercises to increase strength, exercises to restore support capacity and swing phase of the step, improving functional status, exercises to improve postural control and balance, exercises to restore the amplitude, increase strength and improve functioning of the upper limb and hand.

Strength exercises were performed every other day during all three periods of rehabilitation to restore walking pattern. In the case of plantarflexion contractures were used: therapeutic exercises from the standing starting position on flat surfaces and stairs. Selection of an orthosis with fixation of the foot in the neutral position + 5°. To increase the strength of dorsal flexors: getting up from surfaces of different heights; motor tasks for step over the objects of different heights; walking while pushing various objects using the affected foot with a load, on an inclined plane, stairs, backward and sideways; ball exercises. In case of proprioception dysfunction: exercises from the starting position standing, the affected leg ahead, transfer of weight to the affected leg with a change of position in the knee joint, on an unstable surface; movements in the affected limb blindfolded; rising of the toes at different angles and with different degrees of support. To correct the position of the pelvis in the single-support phase of walking, exercises were done from the starting position standing, leaning the affected side against the wall - abduction of the opposite limb. To increase the functioning of the hand and arm, actively worked on: stability of the postural muscles of the torso; per-

forming active physical exercises from different starting positions; the activity of the muscles of the torso, shoulder joint, and rotational cuff muscles; normalization of the position of the scapula; improving the reaching and griping of objects of different shapes and sizes in different planes; improving sensory perception in the affected limb.

The main motor tasks of the restoration of the hand were: training of the wrist extension with abduction and extension of the thumb; increase the grip amplitude; achieve the necessary sensory connection with the object managing vision control levels; simultaneous use of both hands.

In the second rehabilitation period correlation of the exercises to solve problems at different levels was as follows: problems at the level of structure and function – 20%, at the level of activity – 50%, at the level of participation – 30%. Patient's functionality made it possible to perform more activity-level tasks and increase participation. This period included: exercises to restore the amplitude and increase strength, improve vestibular responses, increase cardiorespiratory endurance, motor tasks to improve self-care and daily activities, improve cognitive abilities. Increased endurance was achieved by walking 10 - 15 minutes at a target heart rate of 55 -65% of maximum. Improved the ability to reach a certain object using exercises with changing speed, visualization of the target, sliding on the surface when approaching the object; exercises for reaching the subject and hitting it. All exercises were performed with motivation to move and individually selected goal-oriented tasks.

In the third period of rehabilitation correlation of the exercises to solve problems at different levels was as follows: 20% – at the level of structure and function, 30% – at the level of activity, 50% – at the level of participation. Functional condition and activity level made it possible to perform tasks at the level of participation. The third period included: exercises to improve and maintain the range of motion, increase strength, restore the previous level of cardiorespiratory endurance, motor tasks to improve self-care skills, exercises for coordination, balance, agility. Providing independent long-term movement in space, modeling of life situations, adaptation to environmental conditions and independent stay in it.

Within the breaks between the periods of the rehabilitation course, conducted at the inpatient unit, patients of the EG were given individual tasks and exercises that had to be performed at home. Such home tasks were aligned with the goals of the patient and his/her family.

Physical rehabilitation effectiveness was measured with the help of clinical tests at the initial, intermediate and final stages of the study. Within the physical rehabilitation course, indicators of lower and upper limb muscle strength, spasticity level, equilibration level and risk of falling, self-maintenance degree and dependence on outside help, fatigue level, walking pace and duration and cognitive condition level were monitored.

Physical rehabilitation comprehensive course was followed by the assessment of its effectiveness: data on changes in the functional state, intensity of motor and sensorimotor disorders were collected.

Research methods and their use have been selected depending on the task of study and methodological approach of the ICF. The spasticity rate was determined using the Ashworth Spasticity Scale. The Barthel Index was used to assess independence in the everyday life. The disability rate (functional dependence) was determined using the modified Rankin scale. Postural abilities were assessed using the Berg balance scale and the Tinnety Test. Mobility was assessed using the Rivermead Mobility Index and the Fugl Meyer Stroke Sensory Motor Scale. Muscle strength was determined using a modified Motor Verticalization Control Test. The walking rate was assessed by the 6-minute walk test (6MWT). The intensity of physical activity was determined according to the Borg individual load perception scale. The level of mental status - according to the SAGE test.

Statistical analysis

All statistical analyses were conducted using SPSS 21.0 program (Chicago, IL, USA). Mean ± standard deviation (M±SD), median (Me), upper and lower quartiles (25%; 75%) were measured. Correspondence between the type of quantitative indicators distribution and the normal distribution law was analyzed with the help of Shapiro-Wilk's test. To measure the significance of the difference, Student's t-test (for dependent groups) was used provided there was a normal distribution of study results. Wilcoxon test (for dependent groups) and Mann-Whitney U test (for independent groups) were used provided the indicators had a distribution other than normal. Statistical significance defined at $p<0.05$.

Results

According to the results of the ascertaining experiment, the patients had similar indicators with a slight, more marked and considerable increase in muscle tone on Ashworth Spasticity Scale. Muscle strength indicators measured by Motor Verticalization Control were 11.44±0.23 points, which comprised only 49.7% of the maximum; Me (25%; 75%) indicators were 12.0 (10.0; 13.0) points.

Berg balance test revealed a high level of falling among all patients. Total Berg balance test score was 28.84±7.23 points, Me (25%; 75%) indicators comprised 30.0 (23.0; 35.0) points. Mean value comprised 51.5% of the maximum. Among the results obtained, the minimum score comprised 12 points and the maximum score comprised 42 points. Besides, none of the patients had a score higher than 45 points and, accordingly, all patients had a high level of falling.

Mid-test results on the Rankin scale comprised 1.83±0.62 and 2.13±0.74 points in EG and CG, Me (25%; 75%) indicators were 2 (2; 2) and 2 (2; 3) respectively. At this stage, no statistical difference was observed between the groups ($p=0.086$, $Z=-1.719$), though a significant improvement was observed in both groups as compared to the pre-tests ($p<0.01$).

The Rivermead Mobility Index comprised 44% of the maximum score. The highest proportion of patients received 7 (21.9%), 6 (20.5%) and 12 (16.4%) points.

The assessment of hand and wrist motor functioning on the Fugl-Meyer scale revealed an average score of 10.1±3.88 points, which comprised 41.96% of the maximum. The average Barthel Index comprised 67.95±12.04 points. 41.1% of the patients had a considerable degree of dependence, the rest – a moderate one. The Tinetti Test assessing balance and risk of falling also showed low results.

The average distance of 6-MWT patients was 100.22±58, 14 m when Borg scale of perceived exertion comprised 4.82±1.37 points. More than half of the sample (56.2%) had normal cognitive functions on the SAGE scale.

Thus, the results obtained at the first stage of the preliminary studies reveal significant limitations in each of the domains of the ICF, which requires physical rehabilitation.

The data obtained upon completion of the rehabilitation course indicate positive dynamics of the studied indicators. Decreased spasticity level was observed in both groups. On Ashworth Spasticity Scale mean value difference in the groups was 0.4 points and was significant (p=0.000, t=-3.785). Muscle strength increase was higher in EG, as indicated by the total score increase of Motor Verticalization Control. It was more significant among EG patients – 43% of the maximum, which influenced statistical difference between the groups.

A difference (p=0.000, t=6.860) was also observed in the total score of Berg balance test. Mean values in the EG comprised 44.9±5.79 points and in the CG – 35.2±6.27 points. There was a decrease in disability level in EG. On the Rankin scale the average score was significantly (p=0.007, t=-2.763) better in EG and comprised 1.11±0.62 points.

Patients' overall mobility improved in the Rivermead Mobility Index as well: at the end of the rehabilitation course, it comprised 11.97±1.42 among EG patients and 9.47±1.81 points among CG patients. The difference between the groups was significant (p=0.000, t=6.574) (Table 1).

Table 1. Dynamics of the Rivermead Mobility Index in the Experimental Group and Control Group of the patients, M±SD

Rivermead Mobility Index	EG	CG	t	p
Pre-test	6.23±1.83	6.95±1.74	-1.716	0.091
Mid-test	9.17±1.74	8.29±1.81	2.119	0.038
Post-test	11.97±1.42	9.47±1.81	6.574	0.000

Legend: EG - Experimental Group; CG - Control Group

According to Barthel Index EG had significantly better (p=0.000, t=5.234) results, with a 10 point superiority between mean values and better distribution of activity indicators in daily life.

The total score of the Tinetti Test assessing balance and risk of falling comprised 35.8% of the maximum among EG patients, and 15.8% – among CG patients (p=0.000, t=6.918).

Despite statistical improvements in the final results of walking tests (as well as 6-MWT) and Borg scale scores, statistical analysis revealed better results of CG patients.

After completion of the course most EG and CG patients had normal cognitive functions according to SAGE scale – 91.4% and 84.2% respectively. However, the difference indicated the superiority of EG results (p=0.012, Z=-2.505).

At the end of the rehabilitation course, there was an increase in functioning and improved motor control of an upper extremity. The dynamic of indicators of hand and wrist motor functioning on the Fugl-Meyer scale was statistically significant, as well as the difference of this index between the groups (p=0.010, t=2.653) (Table 2).

Table 2. Dynamic of mean values of the Fugl-Meyer total score ("wrist" and "hand" blocks) in the Experimental Group and Control Group of the patients, M±SD

Fugl-Meyer total score	EG	CG	t	p
Pre-test	9.29±3.37	10.79±4.22	-1.688	0.096
Mid-test	13.20±3.76	12.45±4.38	0.789	0.433
Post-test	16.91±3.85	14.29±4.60	2.653	0.010

Discussion

The data obtained confirm that using physical rehabilitation rationally (in particular controlled physical activity) increases functionality and improves the life quality of the patients with the consequences of cerebral blood flow acute disorders (Hesse et al., 1995; Visintin, Barbeau, Korner-Bitensky, & Mayo, 1998; Bohdanovska & Kalenova, 2018), who also offer training vertical posture by on-load walking on a treadmill. Thus, according to the results of 6-MWT after the rehabilitation course, EG patients' average result was 178 m. CG patients' average result was only 107 m. EG patients were able to cover longer distances in less time, which significantly influenced their mobility and ability to walk in the streets of a city that raised their independence and improved life quality.

Study results substantially supplement the data (Holik, 2011; Rokoshevska & Kruk, 2016) that research methods and their application time were determined by the research objectives and methodological approach according to the ICF. The ascertaining experiment was conducted to obtain baseline indicators of neurological damage degree at the level of functions and structures, activity and participation. The selected research methods contributed to a detailed and comprehensive analysis of sensorimotor disorders of the patients with the consequences of cerebral blood flow acute disorders in the late recovery period.

Study results substantially supplement the data (Lazarieva, 2015; Bohdanovska & Kalenova, 2017) that the proposed method of functional training contributes to the restoration of sensorimotor functions, improvement of motor functions and increase of the adaptation and compensatory potential of the CNS of the patients with cerebral blood flow acute disorders in the late recovery period.

Thus, the introduced physical rehabilitation program, featuring a comprehensive approach aimed to increase upper extremity functionality and restore optimal statics and balance for the patients with the consequences of cerebral blood flow acute disorders in the late recovery period, can increase functionality more efficiently and improve patient's life quality.

Our physical rehabilitation program for patients with post-stroke disorders in their late recovery period is based on modern methodological approaches of the ICF which helps to restore functionality, increase maximum activity, and participation. The results offered can be used to create 3 to 12-month rehabilitation programs for patients with post-stroke disorders who are in rehabilitation departments, centers, and at home during recovery.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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