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Efficacy of Physical Rehabilitation of Patients in the Early Period of Ischemic Stroke Using Stabiloplatfom and Balancing Platforms

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ABSTRACT

AIM. The aim of the study was to develop a comprehensive physical rehabilitation program based on the use of stabiloplatfom and balancing platforms and to assess the effectiveness of its use in patients in the early period of ischemic stroke at the inpatient stage.

MATERIALS AND METHODS. The study was conducted on the basis of the Department of Restorative Medicine and Rehabilitation of the Medical Complex of the Far Eastern Federal University. Depending on the physical rehabilitation program, three groups were formed by random sampling, comparable in gender, age, presence of risk factors for ischemic stroke, severity of patients. All three groups received drug therapy, neurorehabilitation and physical rehabilitation. The EG1 included patients who were given therapeutic gymnastics classes using balancing platforms. Patients of the EG2 also conducted therapeutic gymnastics classes using balancing platforms and additional training sessions on the stabiloplatfom of the ST-150 (Mera-TSP LLC, Russia) with biological feedback. The CG included patients who were engaged in therapeutic physical education under a program provided for neurological patients, which has a general strengthening effect, contributing to the restoration and improvement of self-care skills, balance and movement functions.

RESULTS AND DISCUSSION. Despite advances in medical practice, the task of eliminating the consequences of a stroke remains unresolved. Disability after a stroke is a large percentage, and the search for new technologies to solve the problem of restoring lost body functions, improving the quality of life, returning to normal work is especially significant today. Before the start of comprehensive physical rehabilitation, when analyzing the results of the primary study of patients who had a stroke, according to various tests, movement disorders, imbalances, postural balance were observed. All patients had self-care and mobility problems and needed outside help, all had reduced quality of life scores. The results of the final (after completion of the physical rehabilitation course) testing of maintaining vertical posture and balance, mobility, balance, restoration of social independence and quality of life of stroke patients made it possible to prove the effectiveness of the treatment gymnastics complex using unstable balancing platforms and training on stabiloplatfom.

CONCLUSION. The developed comprehensive physical rehabilitation program using unstable balancing platforms and training on stabiloplatfom to a greater extent than the traditional therapeutic physical culture program provided for neurological patients contributed to increasing the degree of independence, self-care and mobility in everyday life, reducing the level of personal and situational anxiety, improving the psycho-emotional status of patients.

KEYWORDS: force plate, stabilometric platform, physical rehabilitation, stroke patients.

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Эффективность физической реабилитации пациентов в раннем периоде ишемического инсульта с использованием стабилоплатформы и балансировочных платформ

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РЕЗЮМЕ

ЦЕЛЬ. разработка комплексной программы физической реабилитации на основе использования стабилоплатформы и балансировочных платформ и оценка эффективности ее применения у пациентов в раннем периоде ишемического инсульта на стационарном этапе.

МАТЕРИАЛЫ И МЕТОДЫ. Исследование проводилось на базе отделения восстановительной медицины и реабилитации Медицинского комплекса Дальневосточного федерального университета. В зависимости от программы физической реабилитации методом случайной выборки было сформировано три группы, сопоставимые по полу, возрасту, наличию факторов риска развития ишемического инсульта, степени тяжести пациентов. Все три группы получали медикаментозную терапию, нейрореабилитацию и физическую реабилитацию. В ЭГ1 вошли пациенты, которым проводились занятия лечебной гимнастики с использованием балансировочных платформ. Пациентам ЭГ2 также проводились занятия лечебной гимнастики с использованием балансировочных платформ и дополнительно сеансы тренировочных занятий на стабилоплатформе ST-150 (ООО «Мера-ТСП», Россия) с биологической обратной связью. В КГ вошли больные, которые занимались лечебной физической культурой по программе, предусмотренной для неврологических больных, оказывающей общеукрепляющее действие, способствующей восстановлению и улучшению навыков самообслуживания, функции равновесия и движения.

РЕЗУЛЬТАТЫ И ОБСУЖДЕНИЕ. Несмотря на достижения в медицинской практике, задача ликвидации последствий перенесенного инсульта остается нерешенной. Инвалидизация после инсульта составляет большой процент, и поиск новых технологий решения проблемы восстановления утраченных функций организма, повышения качества жизни, возвращения к нормальной трудовой деятельности является на сегодняшний день особенно значимым. До начала комплексной физической реабилитации при анализе результатов первичного исследования пациентов, перенесших инсульт, по различным тестам, наблюдались двигательные расстройства, нарушения равновесия, постурального баланса. Все пациенты имели проблемы с самообслуживанием и мобильностью и нуждались в посторонней помощи, у всех были снижены показатели качества жизни. Результаты итогового (после завершения курса физической реабилитации) тестирования поддержания вертикальной позы и равновесия, мобильности, баланса, восстановления социально-бытовой независимости и качества жизни пациентов, перенесших инсульт, позволили доказать эффективность воздействия комплекса лечебной гимнастики с использованием нестабильных балансировочных платформ и тренинга на стабилоплатформе.

ЗАКЛЮЧЕНИЕ. Разработанная комплексная программа физической реабилитации с использованием нестабильных балансировочных платформ и тренинга на стабилоплатформе в большей степени, чем традиционная программа лечебной физической культуры, предусмотренная для неврологических больных, способствовала повышению степени независимости, самообслуживания и мобильности в повседневной жизни, уменьшению уровня личностной и ситуативной тревожности, улучшению психоэмоционального статуса пациентов.

КЛЮЧЕВЫЕ СЛОВА: силовая пластина, стабилметрическая платформа, физическая реабилитация, пациенты с инсультом.

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INTRODUCTION

The disability of the stroke patients is mainly due to the severity of motor disorders. According to the research data, no more than 15.0 % of the patients return to work after a stroke, a third of whom are people of working age [1,2]. The frequency of strokes in able-bodied persons aged 25–65 years is 2.5–3 cases per 1000 people for the urban population, and for rural 1.9 cases per 1000 people [3]. At the same time, the state program "Health Development", proved by the Government of the Russian Federation on December, 26, 2017, pays special attention to the problems of health of the able-bodied population [4]. When physically rehabilitating patients who

have had a stroke, stabiloplatfoms are successfully used, which allow us to provide an objective assessment of the pathology of the equilibrium function, peripheral nervous system, pathology of the vestibular and visual analyzers, and assess the functional state of the human nervous system according to the principle of biological feedback [5–8]. The analysis of the available literature reveals that the data of the biofeedback received at the force plate, are not always used as a simulator of the motor impairment and control of the effectiveness of the complex physical rehabilitation of the stroke patients and today there is a need to obtain an evidence base on the use of the force plate [9–12].

AIM

To develop a comprehensive physical rehabilitation program based on the use of stabiloplatform and balancing platforms and to assess the effectiveness of its use in patients in the early period of ischemic stroke at the inpatient stage.

MATERIALS AND METHODS

The study was conducted on the basis of the Department of Restorative Medicine and Rehabilitation of the Medical Complex of the Far Eastern Federal University (minutes of the meeting of the Local Ethics Committee No. 87, 07.06.2021). To describe the initial condition of the patients after the ischaemic stroke, the analysis of the medical documentation (outpatient cards, patient medical records) were used. Three groups were formed by random sampling in depending on the programme of the physical rehabilitation. The group of the surveyed people included 42 people, 30 of whom composed two experimental groups (EG1, EG2) of 15 persons in each and 12 persons composed the control group (CG). The EG1 included the people who received the therapeutic exercises using the balancing platforms. At the same time, exercises of therapeutic physical culture were selected individually, depending on the severity of paresis and functional disorders. The complex of therapeutic gymnastics using unstable balancing platforms included exercises on thick mats, fitbols, balancing pads of various modifications. The EG2 patients also received therapeutic gymnastics sessions using the balancing platforms and additionally the training sessions on the force plate with biofeedback. Training using different targets made it possible to objectively record the dynamics of equilibrium function in patients through feedback channels. The patient, standing barefoot vertically on a stabilometric platform ST-150 («Mera-TSP» LLC, Russia) and keeping his hands along the body, looks at the monitor located in front of him at a distance of 2 meters. The projection of the patient's center of gravity onto the stabilometric platform (center of pressure) is visualized on the screen as a "mark." To achieve the task, the patient needed to hold the "label," the image of which was created by the software on the screen for 60 seconds. Visualized data on the movement of the patient's common pressure center were used to organize biofeedback trainings. The training on a stabilometric platform made it possible to use several systems at the same time — the visual analyzer, the vestibular system and the muscle apparatus, which had a complex effect on the patient's body. Thus, the means of rehabilitation were aimed at the active participation of the patient in the rehabilitation process, increasing the motivational orientation and included an active motor regime. Sessions on a stabilometric platform and the use of biofeedback contributed to the correction of posturological disorders — balance, vertical posture retention. The CG included the patients engaged in the exercise therapy according to the programme specified for the neurological patients, providing the general tonic effect, contributed to the recovery and improving the self-care skills, balance and motor functions. The structural component of the programme on the basis of the use of the balancing platforms of different kinds, based on the principle of stage-by-stage approach and used by us during the process of rehabilitation of the post-stroke patients are different movements, assisting to the formation of balance and equilibration, dexterity training

and movement coordination of the lower and upper limbs. The programme of the movement correction was designed individually depending on the initial characteristics of the pathologic movement pattern of the patient. Exercises of individually oriented therapeutic gymnastics using balancing platforms were consistent with breathing exercises and were performed symmetrically with musical accompaniment. The rehabilitation course in all groups consisted of 14 classes, lasting from 30 to 45 minutes. The training program was developed taking into account the need to solve the following tasks:

- expanding the patient's motor activity by restoring the strength of paralyzed muscles and compensating for movement disorders;
- mastering vertical position and walking, self-service skills;
- psychological and social adaptation.

Patients from all groups (EG1, EG2, CG) in addition to standardized therapy, received massage sessions, physiotherapy, neurorehabilitation, magnetotherapy, kinesiotaping, active-passive mechanotherapy. In addition, all patients underwent psychotherapy sessions aimed at correcting the psychoemotional state. Emotional support was aimed at overcoming the identified violations based on preserved functions, correcting experiences and set goals, restoring a holistic perception of oneself with the formation of readiness to accept responsibility for one's own health, developing a positive attitude to forced changes in life, and improving social interaction. A mandatory addition to this complex was relaxation, self-training and visual imaging. We used several tests to characterize the values of balance, mobility and self-care: Berg balance scale (BBS), Tinetti scale, Timer Walking Test, Barthel index, stabilometrics. The BBS made it possible to assess the possibility of subjects to maintain balance, make transitions from sitting to standing position and back, make turns and turns and perform exercises of various complexity. The severity of the existing violations was assessed by the number of points based on the ability of the subject to independently perform 14 tasks in accordance with certain time and distance requirements. Each component was evaluated on a five-point ordinal scale from 0 (failure to complete the task) to 4 (normal). It was necessary to score 56 points, which corresponded to the norm. To prevent the risk of falling stroke patients, we used Tinetti mobility measures. The test allows you to assess the balance during turns, gait, the need to use walking aids (crutch), and the presence of outside support. The severity of violations was assessed in points. The assessment of the level of daily activity was carried out by calculating the Bartel index, which covers 10 points related to the field of self-service and mobility. At the same time, the maximum amount of points corresponding to complete independence in everyday life is 100. The Timer Walking Test was used to identify local functional abnormalities and assess functional mobility, recording the distance a patient could travel in 6 minutes and the speed of movement. To characterize the values of life quality and degree of independence in daily activities we used the questionnaire MOS SF-36 (J.E. Ware, 1992) and its Russian version SF-36 (according to A.N. Belov's questionnaire) for studying all the components of life quality. This questionnaire allowed us to give the complex assessment of the physical, psychological, emotional and

social functioning, determine the degree of independence in daily life and measure self-care and mobility (walking, moving, climbing and descending stairs) of stroke patients, assess their quality of life. The determination of indicators of the level of situational and personal anxiety was carried out according to the method of C.D. Spielberger, adapted by Yu. L. Khanin. The results of the study were processed using the following methods of mathematical statistics: the method of determining the arithmetic mean indicator and the method of determining the growth rates of indicators V.I. Usakova. The validity of the differences in the obtained data according to the Student's t-test was determined at the normal Gaussian distribution. Differences at $p < 0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

The study participated 42 patients, 28 men (66.6 %) and 14 women (33.4 %). The study included patients whose stroke occurred from 2 weeks to 1 month ago — 5 people (11.9 %), patients whose stroke history ranged from 1 to 3 months — 33 people (78.5 %), and patients with stroke history from 4 to 6 months — 4 people (9.6 %). From the point of view of restoring the functions and tasks of rehabilitation (A.S. Kadykov), the patients whose time after a stroke ranges from 2–3 weeks to 6 months belong to the early recovery period. The age of the tested persons varied from 25 to 80 years. The most numerous occurred the age group from 51 to 60 years — 13 people (30.9 %) and the age group from 61 to 70 years — 12 people (28.5 %). 46.0 % of them were the active working age. Only men were the patients in the age group of 25–40 and 71–80 years. Such risk factors as smoking and alcohol overuse were observed in 23 people (54.7 %) and 13 people (30.9 %) correspondingly. The arterial hypertension was observed in 22 people (52.3 %), atherosclerosis — in 25 people (59.5 %), the combination of arterial hypertension and atherosclerosis was observed in 18 people (42.8 %), discirculatory encephalopathy was observed in 17 patients (40.4 %), ciliary arrhythmia — in 14 patients (33.3 %), ischemic heart disease — in 21 people (50.0 %), chronic cardiac insufficiency in 12 patients (28.5 %) and diabetes mellitus in 6 patients (14.2 %). The concomitant diseases (pneumonia, urinary tract infections, and thrombophlebitis) were observed in 17 patients (40.4 %).

12 (28.5 %) people suffered from obesity, the stressful situation during 6 months before the stroke was observed in 24 (57.1 %) people, and the low physical activity was in 29 people (69.0 %). Thus, modifiable risk factors such as smoking, alcohol consumption, low physical activity and hypertension played a significant role. At the same time patients had from 2 to 4 risk factors. The movement disorders, balance disorders, postural balance disorders observed before the start of the complex physical rehabilitation at the outcome analysis of the initial examination of the patients after the stroke according to different tests. All the patients had the problems with self-care and mobility and required outside help; all of them had the reduced indicators of quality of life. The developed comprehensive physical rehabilitation program using unstable balancing platforms and training on stabiloplatform to a greater extent than the traditional therapeutic physical culture program provided for neurological patients contributed to increasing the degree of independence, self-care and mobility in everyday life, reducing the level of personal and situational anxiety, improving the psycho-emotional status of patients [13,14]. The study made it possible to prove positive changes: according to Berg Balance Scale in CG the indicators increased by 19.2 % (from 35.5 to 42.3 points), in EG1 — by 26.2 % (from 35.5 to 44.8 points) and in EG2 — by 29.6 % (from 36.1 to 46.8 points). According to the results of the Bartel Index, the increase in the level of household activity related to the self-service sector: in CG by 15.8 % (from 61.5 to 71.2 points), in EG1 by 18.6 % (from 62.2 to 73.8 points) and in EG2 by 26.9 % (from 62.1 to 78.8 points). There was a significant ($p < 0.05$) improvement of the balance and walking parameters, estimated according to the Tinneti scale, that reduced the risk of falling of the patients in EG2 by 41.0 % (in CG by 24.0 %, in EG by 27.0 %). When the balancing platforms and trainings on the force plate are included into the programme of the physical rehabilitation, reliable improvement of the locomotor function indicator ($p < 0.05$) compared with the initial values in the all groups according to the Time Walking Test of the speed indicators of walking and covered distance. The positive impact of the programme of the physical rehabilitation with the use of the balancing platforms and training on the force plate upon the increasing of the independence degree was observed,

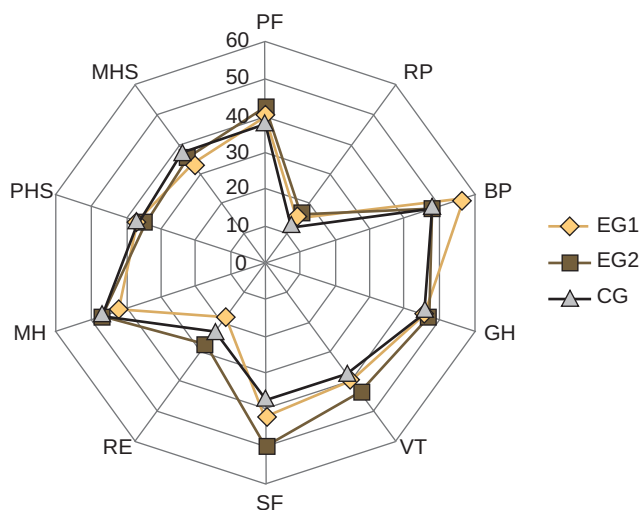


Fig. 1. Quality of life indicators of stroke patients before the physical rehabilitation ($n = 42$)

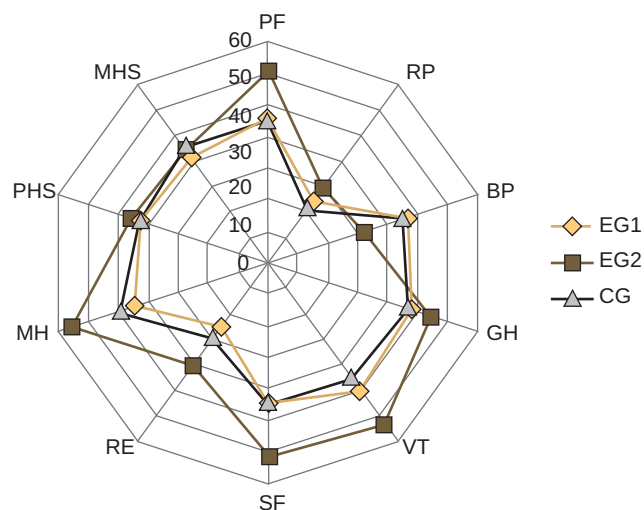


Fig. 2. Quality of life indicators of stroke patients after the physical rehabilitation ($n = 42$)

and consequently the improvement of the quality of life was observed in EG2, where the PF indicator achieved 61.1 points. The higher values according to the subscales VT (62.7 points) and MH (65.7 points), SF (61.1 points) out of maximum 100 were also registered in this group (Figure 1, 2). The RP indicator, objectifying the degree of physical well-being influence upon the daily life, increased during the treatment process, at the same time remaining at rather low level (29.5 points). The less significant improvement was revealed according to the subscales, forming the psychological component of the quality of life. The significant ($p < 0.05$) decrease of the personal (by 30.35 %) and state (by 25.6 %) anxiety among the patients of EG2 was found, characterizing the increase of the activity and motivation of the patients to work and responsibility in solving their health problems. The analysis of the indicators of the stabilometrical research demonstrated positive changes in the balance of the verticalis standing and walking.

It was found that the area of pressure center and its vibrations, measured in the frontal and saggital planes significantly change. The speed of the pressure center, the total amplitude in the frontal plane and the square (S , mm^2) of the statokinesiograms ($p < 0.05$) significantly decreased (Table 1).

mobility, restoration of the social-domestic independence and quality of life of the stroke patients made it possible to prove the effectiveness of the therapeutic exercises complex using unstable balancing platforms and trainings on the force plate. At the current stage, it remains relevant to develop physical rehabilitation programs that increase the effectiveness of the recovery process for patients who have had a stroke in the early recovery period, including unstable balancing platforms and training on stabiloplatform.

CONCLUSION

Testing of the initial state of patients at the preliminary stage of the study revealed a violation of motor function, a decrease in quality of life, an imbalance in the psycho-emotional state of patients in the early period of ischemic stroke at the inpatient stage. A close relationship was established between improving the function of body balance, the patient's ability to maintain a stable vertical position of the body in space when walking, during motor actions and improving the quality of life. The obtained results confirmed the high efficiency of integrated physical rehabilitation using unstable balancing platforms and training on stabilometric platform aimed at increasing mobility, balance, improving motor qualities, improving the quality of life of stroke

Table 1. The area of the pressure center and the speed of its movement in patients after a stroke before and after physical rehabilitation ($n = 42$)¹

Test results	EG1 ($n = 15$)		p	EG2 ($n = 15$)		p	CG ($n = 12$)		p
	before	after		before	after		before	after	
S (o), mm^2 (open eyes)	429 [380; 441]	347 [326; 358]	0.025	307 [290; 315]	239 [326; 358]	< 0.01	427 [410; 445]	305 [286; 320]	< 0.05
S (c), mm^2 (close eyes)	660 [642; 678]	541 [530; 552]	0.025	646 [628; 662]	505 [490; 512]	< 0.01	651 [630; 670]	580 [558; 596]	< 0.05
V (o), mm/s (open eyes)	14 [12; 16]	11 [9; 13]	0.025	14 [13; 15]	11 [9; 13]	< 0.01	14 [12; 16]	12 [10; 14]	< 0.05
V (c), mm/s (close eyes)	23 [21; 25]	20 [18; 22]	0.025	18 [17; 19]	11 [10; 12]	< 0.01	20 [18; 21]	19 [18; 20]	< 0.05

Note: ¹The analysis of intra-group differences was carried out according to the Mann-Whitney criterion.

The decrease of the average balancing parameters was registered in the group with open eyes S (o), mm^2 in EG2 by 54.7 %, while in the CG — by 39.9 % and in EG1 by 23.7 %. The change of the balancing parameters was found in the group with close eyes S (c), mm^2 in EG2 by 28.7 %, while in CG by 12.1 % and in EG1 by 22.0 %. Significant reducing of the results of conveyance speed of pressure center was found in the patients with open eyes V (o) in EG2 by 27.1 %, while in CG it decreased by 18.9 % and in EG1 by 21.0 %. A significant decrease of the results of conveyance speed of pressure center was found in the patients with closed eyes V (c) in EG2 by 40.1 % while in CG it decreased by 4.5 % and in EG1 by 12.8 %. The patients of EG2 achieved the statutory indicator to the fullest extent V (o) = 10.9 mm/s at the norm < 10.6 and to the statutory indicator V (c) = 11.1 mm/s at the norm < 11.5. In CG and EG1 these indicators differed from the standard ones. These changes objectively reflect the improvement of balance stability. Thus, the results of the final test of the support of the vertical posture and balance,

patients at the inpatient stage in the early recovery period. At the current stage, it remains relevant to develop physical rehabilitation programs that increase the effectiveness of the recovery process for patients who have had a stroke in the early recovery period, in which, among other things, unstable balancing platforms and training on stabilometric platform can be used. Thus, a comprehensive physical rehabilitation program developed and tested in the conditions of the Center for Restorative Medicine and Rehabilitation of the Medical Center of the Far Eastern Federal University using unstable balancing platforms in therapeutic physical culture and training on stabilometric platform with biological feedback to a greater extent. than the standard therapeutic physical education program provided for neurological patients, promotes independence, self-care and mobility in daily life, accompanied by a decrease in the level of personal and situational anxiety, an improvement in the psycho-emotional status of stroke patients in the early recovery period of rehabilitation.

ADDITIONAL INFORMATION

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contributed significantly to the conception, study design and preparation of the article, read and approved the final version before publication). Special contributions: Kaerova E.V. — formal analysis, writing — original draft; Shakirova O.V. — writing — review & editing; Zhuravskaya N.S. — conceptualization, methodology, validation; Kozyavina N.V. — investigation, data curation.

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Data Access Statement. The data that support the findings of this study are available on reasonable request from the corresponding author.

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