Medical Rehabilitation (Med Rehabil) 2018, 22 (1): 4-14 DOI: 10.5604/01.3001.0011.6826 eISSN 1896–3250 ISSN 1427–9622 © AWF Krakow

The influence of physiotherapy on motor control re-education among patients after ischemic stroke

Wpływ fizjoterapii na reedukację kontroli motorycznej u chorych po przebytym udarze niedokrwiennym mózgu

Katarzyna Zielonka-Pycka [1 (A,B,D)], Elżbieta Szczygieł [2 (B,C,E)], Edward Golec [2 (E,F)]

[1] Doctoral studies, Department of Motor Rehabilitation, Bronisław Czech University School of Physical Education in Krakow, Poland
[2] Facility for Orthopaedic Rehabilitation, Faculty of Clinical Rehabilitation, Department of Motor Rehabilitation, Bronisław Czech University School of Physical Education in Krakow, Poland

Key words
ischemic stroke, postural control, deep muscles

Abstract
Introduction: The authors present the influence of two physiotherapy programmes on the re-education of motor behaviour in patients after ischemic stroke. One of them is a programme based on exercises combining PNF and NTD Bobath elements, while the other is a deep trunk muscle exercises with the use of the PUM armchair.
Material and methods: The study material was a group of 60 patients of both sexes who suffered ischemic stroke resulting in hemiparesis. They were divided into two groups. Group I consisted of 18 women (60%) and 12 men (40%) who followed the author's programme of deep muscle activation exercises using the PUM armchair. Group II consisting of 15 women (50%) and 15 men (50%) followed the exercise programme using standard methods, i.e. based on PNF and Bobath methods.
Results: They indicate the effectiveness of both methods, with the predominance of the author's programme.
Conclusion: The improvement of deep muscle activity in the examined group of patients has positive influence on their muscle tone, balance and postural control, which in turn, reduces muscle tension, improves gait stereotype and load characteristics of lower limbs.

Słowa kluczowe
udar niedokrwienny mózgu, kontrola motoryczna, mięśnie głębokie

Streszczenie
Wstęp: Autorzy pracy prezentują wpływ dwóch programów fizjoterapii na reedukację zachowań motorycznych u chorych po przebytym udarze niedokrwiennym mózgu. Jednym z nich jest program oparty na ćwiczeniach łączących elementy PNF i NTD Bobath, drugi natomiast, to ćwiczenia mięśni głębokich tułowia z wykorzystaniem Fotela PUM.
Materiał i metody: Materiał badań stanowiła grupa 60 chorych obu płci, którzy doznali udaru niedokrwiennego mózgu skutkującego niedowładem połowiczym. Podzielono ich na dwie grupy. Grupę I stanowiło 18 kobiet (60%) i 12 mężczyzn (40%), którzy realizowali autorski program ćwiczeń aktywizujących mięśnie głębokie z wykorzystaniem Fotela PUM. Grupa II to 15 kobiet (50%) i 15 mężczyzn (50%), którzy realizowali program ćwiczeń metodami standardowymi tzn. w oparciu o trening metodą PNF i Bobath.
Wyniki: Wskazują na skuteczność obu metod, z przewagą programu autorskiego.
Wnioski: Poprawa aktywności mięśni głębokich wpływa korzystnie na ich napięcie mięśniowe, równowagę i kontrolę posturalną. Zmniejsza napięcie mięśniowe, poprawia stereotyp chodu i charakterystykę obciążania kończyn dolnych.

The individual division of this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

Article received: 30.01.2018; Accepted: 30.03.2018

Please cite as: Zielonka-Pycka K., Elbieta Szczygieł E., Edward Golec E. The influence of physiotherapy on motor control re-education among patients after ischemic stroke. Med Rehabil 2018; 22(1): 4-14. DOI: 10.5604/01.3001.0011.6826

Internet version (original): www.rehmed.pl

Medical Rehabilitation (Med Rehabil) 2018, 22 (1): 4-14 DOI: 10.5604/01.3001.0011.6826 eISSN 1896–3250 ISSN 1427–9622 © AWF Krakow

INTRODUCTION

Strokes are one of the most common causes of severe physical and intellectual disabilities in the adult population. According to the National Stroke Association, approximately 795,000 patients are yearly registered with primary or secondary strokes[1]. About 60% of them are affected by various degrees of motor deficits, while 50% are not independent and require constant treatment, rehabilitation and social care[2]. Therefore, strokes constitute a very serious medical, social and economic problem[3].

This disease is mainly due to sudden impairment of cerebral circulation leading to the hypoxia of nerve cells, and thus, to their impaired functioning[4,5]. Typically, the consequence of the said process is long-term physical disability of these patients, sometimes combined with their cognitive impairment. Symptoms damaging mental efficacy include, among others, language and executive function impairment, difficulties in concentration and problems with memorization and visual-spatial orientation[6]. However, motor deficits prevail in the clinical image of strokes, becoming one of the key problems of these patients. They are mainly related to the impairment of motor control of the trunk, which affects both the correct position of the centre of gravity and maintaining a straightened position of the body, as well as selective movements and sensory-motor skills[7]. Along with existing paresis and muscle tension disorders, an extremely important factor affecting the stability of the body is the optimal positioning of the individual parts of the links of the biokinematic chain ensuring balancing forces of gravity and, at the same time, minimal energy expenditure[8]. Lack of stability triggers compensatory postural and pathological motor patterns[9,10]. Barnes[11] claims that this contributes to the increase of spastic tension. In turn, Pinto et al.[12] confirm that it is also the cause of increased risk of falls in this group of patients.

These problems cause the everyday functioning of patients after stroke to significantly change, and their quality of life becomes significantly reduced[5]. At the same time, many authors agree that adequate deep muscle activity is a factor conditioning stability[13,14,15]. The most important role of these muscles is their proportional and even activation in order to ensure proper movement patterns in functional areas during everyday activities. It seems that the introduction of deep muscle training would be justified in achieving improvement in central stabilization in order to improve the functioning of patients after ischemic stroke.

Among the many methods used to rehabilitate stroke patients, Propirioceptive Neuromuscular Facilitation (PNF) and the Bobath neuro-developmental treatment concept (NDT)[16] are the most popular. According to Pollock et al.[17], despite the scientific justification for their use in the group of patients in question, none of these concepts has been explicitly confirmed by reliable scientific research. The large number of recommended methods and exercises in the rehabilitative treatment of patients after ischemic stroke, and at the same time, their effects not being satisfactory, lead to an attempt to define the factors determining the effectiveness of motor control re-education. For the authors, this stance became the basis for undertaking research.

STUDY AIM

The aim of the study was to assess the clinical effectiveness of standard therapy combining elements of PNF and Bobath NTD as well as activation training of selected deep muscle groups in the recovery of motor control among patients after ischemic stroke, and in particular, to answer the following questions:

1. In the studied group, did and to what extent did the applied rehabilitation programmes for patients after ischemic stroke have impact on improving their postural control and tension of selected muscle groups?
2. In the studied group, did and to what extent did the applied rehabilitation programmes for patients after ischemic stroke have impact on improving upper limb function?
3. Does the time of undertaking treatment from the occurrence of the incident have influence on the effectiveness of rehabilitation among patients after ischemic stroke and to what extent does it influence its success?
4. In the studied group, do the applied rehabilitation programmes for patients after ischemic stroke have impact on the re-education of the gait stereotype and the degree of loading the lower limbs and to what extent do they have effect?
5. In the studied group, is there a relationship between intellectual efficiency of those rehabilitated due to previous ischemic stroke and the effects of their treatment programme, and to what extent does this relationship occur?

MATERIAL AND METHODS

The research material comprised a group of 60 patients of both sexes who suffered ischemic stroke resulting in hemiparesis. The time elapsed since the occurrence of the stroke ranged from 6 months to 3 years. The age of the individuals qualified for the study ranged from 45 to 85 years. The rehabilitation of these patients lasted for three weeks. Patients enrolled in the study were assigned to two numerically equal groups using the simple random selection method.

Group I (Gr. I): 30 patients, including 18 women, which is 60% and 12 men, which gives 40% who underwent the exercise programme activating the deep muscles. The programme was created by the authors. Group II (Gr. II): 30 patients, including 15 women, i.e. 50% and 15 men, also equalling 50%, who underwent the exercise programme using standard methods, i.e. based on PNF and Bobath training. The research was carried out at the "Health" Centre for Diagnostics and Therapy in Krakow and at the "Pasternik" Non-Public Health Care Centre in Modlniczka.

The following inclusion criteria were adopted: previous ischemic stroke, time from the onset of the incident from 6 months to 3 years, ability to maintain sitting and standing positions, correct verbal communication, lack of deep spasticity (4° on the Ashworth scale), no stroke in the cerebellum, conscious consent of the patient to participate in the study.

Before and after the treatment, the following activities were performed: I. Evaluation of postural and motor control, which included: assessment of spastic tension using the Ashworth scale, balance assessment and ability to change body posture using the Postural Assessment Scale for Stroke Patients, symmetry assessment of the limbs using the two-weight test, the Tinetti balance and gait assessment scale, the deep sensation test, the Functional Reach Test, and the hand efficiency test using the 9-hole Peg Test. II. Assessment of cognitive disorders by means of the following psychological tests: assessment of the level of anxiety and depression using the Hospital Anxiety and Depression Scale (HADS) and the State-Trait Anxiety Inventory (STAI), assessment of the location of the sense of control using the Multidimensional Health Locus of Control Scale (MHLC).

In the presented study, the following tools were used: Ashworth Scale – to assess the severity of spasticity. It distinguishes 5° of muscle tension found during passive motion. 0° means normal or slightly reduced tension, 4° means deep spasticity[18]. The Postural Assessment Scale for Stroke Patients (PASS) – the scale includes several tasks which are scored from 0 to 3 points, where the number 3 indicates the highest positive result for a given activity, while 0 indicates the inability to execute the task. The scale allows assessment of body transfer and balance. The evaluation takes into account the changes in body position from lying to sitting, from sitting down to standing, maintaining balance in a standing position on both lower limbs and on one, as well as the ability to lift specific objects from the floor[19]. The Tinetti Gait and Balance Instrument serves to evaluate the static, dynamic and gait balance by performing specific tasks scored 0-1-2. The result 0 means that the command cannot be executed. The scale allows assessing the balance in a sitting position, standing with open and closed eyes and body rotation of 360°. It also allows evaluating the gait and its individual components, i.e. step length, step symmetry, gait continuity and gait posture. The two-weight test – allows for assessment of the lower limb symmetrical loading and provides feedback to the subject for correct body positioning, with the aim of symmetrical limb loading[19]. The Functional Reach Test – assessment of upper limb function by determining the change in range of motion in the brachial-scapular joint. The subject assumes upright posture, and then performs the movement of reaching forward using the upper limb without changing the position of the feet. Measurement of the reach range allows assessing changes in upper limb function after the applied treatment[19]. The 9-hole Peg Test – assessment of hand efficacy by placing 9 pins in 9 holes as quickly as possible[20]. Assessment of deep sensation – the patient has closed eyes, the physiotherapist performs passive movements of the subject's limb and instructs him/her to determine the direction of movement and the position of the limbs. The movement begins with the distal parts[19]. The Hospital Anxiety and Depression Scale (HADS) – self-assessment tool for anxiety and depression. The scale has high sensitivity and specificity in the detection of major, generalized anxiety and depressive disorders[21]. The State-Trait Anxiety Inventory (STAI) – a tool designed to study anxiety understood as a transitional state and conditioned depending on the individual's situation and anxiety understood as a relative personality trait[22]. The Multidimensional Health Locus of Control Scale (MHLC) – a self-report tool. It contains statements that concern generalized expectations regarding three dimensions of the location of health control, namely internal, the influence of others, accidental events[23].

Statistical analysis of the results was based on the Wilcoxon Signed-rank test, Spearman's correlation coefficient and the Mann-Whitney U-test. In all the tests carried out, the significance level of 0.05 was assumed. Quantitative variables (expressed in numbers) have been described by mean values, standard deviations, medians, minimums, maximums and quartiles. Qualitative (non-quantified) variables were described by the occurrence frequency of particular values and the percentage distribution.

PUM ARMCHAIR DESCRIPTION

The Positioning Unweight Movement armchair (PUM) (Figure 1) obtained the international patent application number PCT/PL2011/000109[24].

It has a backrest consisting of three separately adaptable parts that can be adjusted to the head (1,2), the chest section (3,4) and LS part of the spine (5). The seat along with the backrest allows small movements in the sagittal and frontal plane (approximately 15°). Support for individual spinal segments, placing them in one line and the possibility of slight movement provide the conditions for dynamic stabilization of the trunk.

PUM armchair – positioning, unweight, movement – allows to be active without the time limits necessary in the case of vertical position. A person sitting in the armchair is forced to constantly maintain balance by engaging the deep muscles of the trunk. In this way, the over-activation of global muscles decreases and stimulates the activity of local muscles responsible for the stabilization of the spine. The PUM armchair provides safety and comfort of modelling the body position by individually adjusting the settings. It creates conditions for smoother movement with minimal force and small deviations. Posture shaped and movement changed in such a manner are accepted by the central nervous system and in the future, are replicated as a new pattern of posture and movement. In addition, it is possible to perform rotational movements in the spine and movements isolated in individual parts of the body or the whole body. The goal of the movement is to stimulate deep sensation by maintaining balance that ensures feeling the feet, knees, hips, spine and upper limbs relative to one another. It reduces the amount of forces that need to be balanced in a vertical position[24].

The PUM armchair allows simultaneous correction of the mutual spatial arrangement of all body segments. No dangers, time for correction, no resistance, low power required for the movement while using the PUM armchair allows to re-induce the movement. The PUM armchair causes the motion to smoothly cover following segments within the accepted range and time of the course. Supporting key body elements in one axis, maintaining balance, dynamic trunk stabilization and small movements of individual body parts create conditions that can contribute to improving motor and postural control in people after ischemic stroke.

Operating principles of the PUM armchair: Grab the stable armrests (8), so that when sitting on a movable seat (10), stable arm support is ensured. When sitting down, the seat support point is found by placing the central part of the pelvis on it so as to obtain support and balance of the lower part of the trunk at the same time. Leaning the lower limbs against the floor, and hands on the stable part of both armrests (8), it should be checked whether the individual is sitting centrally while performing movements with the seat. The correctness of the movement of the lower limbs is very important. The first condition for the correctness of this movement is proper positioning of the feet in the axis of their support (11). The second is the height of foot placement – it is correct when the toes feel the axis of rotation of their support (11). Precision and the type of movement performed depend on the individual predisposition of the patient.

Figure 1

PUM armchair – left side view [original figure]

1 – adjustment of head support depth; 2 – adjustment of head support height; 3 – adjustment of chest support depth; 4 – adjustment of chest support height; 5 – adjustment of lumbar support depth; 6 – reclination adjustment of whole PUM armchair; 7 – movable armrest; 8 – stable armrest; 9 – adjustment of armrest height; 10 – movable seat in all planes; 11 – movable foot support; 12 – movable trolley allowing full extension of the knees.

Each exercise was repeated 15 times, 2 series each. The assumed exercise time was 30 minutes. The therapy lasted for 3 weeks, 5 days a week. The sessions were held both in the morning and afternoon hours. During rehabilitation, the patient was under constant control of a physiotherapist so as to perform precise and correct movements.

Exercises on the PUM armchair proceeded as follows: forward movement of one lower limb until the foot was on the axis of the support (11). Then the knee of this limb was straightened, the other bent. In this condition, the sequence of movement is important, starting from the toes, then the heels, knees, hips, pelvis, spine to the head, small outer or inner rotational movements of both feet transfer movement to the entire spine, extension and flexion of the lower limbs in the knee joint with simultaneous activation of the diaphragmatic airway, the extension of one lower limb in the hip and knee joints is connected with the head turn in the opposite direction to the extended lower limb, pelvis balancing with lower limbs bent and straightened in the hip and knee joints, pelvic lifts with lower limbs extended in the hip and knee joints, upper limb abduction and flexion In the brachial-scapular joint, forward extension and flexion of the trunk, flexion and extension movements of the cervical spine fragment and right and left head turns. After getting up from the PUM armchair, the body's silhouette straightens up spontaneously and freely. This happens for three reasons: activation of local muscles, reduction of pressure on the spine by the global muscles and correction of the body's spatial positioning.

RESULTS

The obtained results are given as average values.

RESULTS OBTAINED FOR PATIENTS FROM GROUP I

On the basis of the conducted tests, before and after the rehabilitation in patients included in Group I, the following were found regarding the analysed variables: FRT – significant improvement, and the average difference was 3.73 cm. Deep feeling – significant improvement was noted, and the number of errors decreased significantly by 0.63. The two-weight test showed significant improvement, and the difference between loading the right and left lower limbs decreased on average by 3.8 kg. PASS – significant improvement was noted, and the average difference was 3.37 points. Tinetti test (balance) – showed significant improvement, and the average difference was 2.27 points. Tinetti test (gait) – significant improvement was noted, and the average difference was 2.13 points. Muscle tension in the right elbow joint significantly improved, and the average difference was 0.37 points. Muscle tension in the right knee joint – significantly improved, and the average difference was 0.53 points. Muscle tension in the right ankle joint – significant improvement, and the average difference was 0.3 points. Muscle tension in the left elbow joint showed significant improvement, and the average difference was 0.27 points. Muscle tension in the left knee joint – significant improvement was noted, and the average difference was 0.47 points. Muscle tension in the left ankle-tibia joint showed significant improvement, and the average difference was 0.27 points. For the remaining variables, no significant differences were observed. The Wilcoxon Signed-rank test was used – distributions of variables significantly differ from those considered normal.

Analysing the studied variables depending on the time elapsed from ischemic stroke to the rehabilitation treatment in Group I patients, the following results were noted: FRT – the longer the time since the onset of ischemic stroke, the smaller the number of centimetres recorded in the test. Deep sensation – the longer the time elapsed since the onset of ischemic stroke, the more errors reported in the test. PASS – the longer the time from the onset of ischemic stroke, the worse the result of this test. Tinetti test (balance) – the longer the time elapsed since the onset of ischemic stroke, the worse the result of this test. Tinetti test (gait) – the longer the time since the onset of ischemic stroke, the worse the result. Muscular tension of the left ankle joint – the longer the time from the onset of ischemic stroke, the more muscle tension was found in the examined joint. In the case of the remaining variables, no significant dependencies were found.

Analysing the impact of paresis location on the results of functional tests obtained after the end of treatment in Group I patients, significant differences were found: two-weight test – difference in lower limb loads was significantly lower in patients with right-sided paresis. Muscle tension in the elbow, knee and right ankle joints – in patients with right-sided paresis, greater muscle tension was found than in patients with left-side paresis. Muscle tension in the elbow, knee and left ankle joints – in patients with left-sided paresis, significantly more muscle tension was observed than in the case of patients with right-sided paresis. In statistical analysis, the Mann-Whitney U test was used.

Analysing the influence of emotional state on the obtained results in Group I patients on the basis of selected psychological tests, no significant differences were observed with respect to gender. The Mann-Whitney U test was used. Analysing the influence of the age of patients from group I after ischemic stroke on the results obtained on the basis of the MHCL test, a significant relationship was found between these variables.

For other indicators, however, no significant relationship was found. In this analysis, Spearman's correlation coefficient was applied. Analysing the influence of the mental state of patients included in Group I on the functional test results obtained by them, there was no significant relationship between these variables. Spearman's test was used in this analysis.

RESULTS OBTAINED FOR PATIENTS FROM GROUP II

On the basis of the conducted tests on patients included in Group II, the following were found regarding the analysed variables: FRT – significant improvement, and the average difference was 1 cm. Deep sensation – significant improvement, and the number of errors decreased significantly by 0.5. PASS – significant improvement, and the average difference was 1.17 points. Tinetti test (balance) – significant improvement, and the average difference was 1.47 points. Tinetti test (gait) – significant improvement, and the average difference was 1.1 points. Muscle tension in the left knee joint – significant improvement, and the average difference was 0.3 points. Muscle tension in the left ankle-tibia joint significantly improved, and the average difference was 0.23 points. For the remaining variables, no significant differences were observed. The Wilcoxon Signed-Rank test was used – distributions of variables significantly differ from normal ones.

When analysing the impact of time elapsed since the onset of ischemic stroke on functional outcome in Group II patients, significant differences were found between these variables. The following were reported: 9-hole Peg test – the longer the time elapsed since the onset of ischemic stroke, the faster the test time. In the case of the remaining variables, no significant dependencies were found. The analysis applied Spearman's correlation coefficient.

Analysing the impact of paresis location on the results of functional tests obtained after the completion of treatment in patients from Group II, significant differences were found: muscle tension in the right elbow, knee and ankle joints in patients with right-sided paresis was significantly greater in the examined joints than in the case of individuals with left-side paresis. Muscle tension in the left elbow, knee and ankle joints of patients with left-sided paresis was significantly higher than in patients with right-sided paresis. The Mann-Whitney U test was used in this analysis.

Table 1

Comparison of treatment results in patients from both groups.

Analyzed variables		**Group I**	**Group II**	**Z**	**p**
FRT [cm]		**3.73**	**1.00**	**2.6390**	**0.0083**
9-hole Peg Test [sec]		1.37	0.53	0.6801	0.4965
Deep sensation [pt]		0.63	0.50	-0.1183	0.9058
Two-weight scale [kg]		3.80	2.60	0.9018	0.3671
PASS [pt]		**3.37**	**1.17**	**2.9643**	**0.0030**
Tinetti balance test [pt]		2.27	1.47	1.9146	0.0555
Tinetti gait test [pt]		**2.13**	**1.10**	**2.9495**	**0.0032**
Examined joints	right elbow [pt]	**0.37**	**0.07**	**1.9885**	**0.0468**
	right knee [pt]	**0.53**	**0.07**	**3.0973**	**0.0020**
	right ankle-tibial [pt]	0.30	0.10	1.1236	0.2612
	left elbow [pt]	0.27	0.03	1.5450	0.1224
	left knee [pkt]	0.47	0.30	1.0645	0.2871
	left ankle-tibial [pt]	0.27	0.23	0.2144	0.8303

Analysing the influence of emotional state on the obtained results in patients from Group II, based on selected psychological tests, no significant differences were observed in accordance to gender. The analysis was based on the Mann-Whitney U test.

Analysing the influence of the age of patients from Group II after ischemic stroke on the results obtained on the basis of selected psychological tests, there were no significant relationships between these variables. In this analysis, Spearman's correlation coefficient was applied.

Analysing the influence of the mental state of patients included in Group II on the obtained functional test results, there was no significant relationship between these variables. Spearman's test was used in this analysis.

Analysing the influence of the level of emotional state on the effectiveness of treatment in Group II patients, there was no significant relationship between these variables. These data were obtained based on Spearman's test.

Analysing the results obtained in both groups of patients included in the study, there were significant differences in the range of results obtained on the basis of FRT, PASS, Tinetti test (gait) and muscle tension within the area of the right elbow and knee joints. In patients included in Group I, greater improvement in the tested variables was found than in the case of patients included in Group II. For the remaining indicators, no significant differences were found. The Mann-Whitney U test was used in this assessment.

DISCUSSION

The trunk is an important part of the human body playing a key role in shaping correct postural conditions, especially during functional movements. This is possible by preparing the body for movement against the force of gravity and the smooth assuming of posture. This view is shared, inter alia, by Olivier et al.[25], who draw attention to the importance of these variables in patients after stroke. In the opinion of Karatas et al.[26], any abnormalities in the normal operation of the trunk lead to impaired peripheral motor functions, and postural control is the basis for body balance. One of the disease entities that impair postural and motor control is undoubtedly ischemic stroke resulting in, among others, hemiparesis. The essential determinants of motor control include: mobility – ability to initiate movement, stability – ability to undertake static and dynamic activity, controlled mobility, dexterity[16].

In our study, the impact of deep muscle activation on the improvement of postural and motor control in people after ischemic stroke was evaluated. Evaluation of postural and motor control was performed through the prism of function evaluation regarding: the trunk, the upper limb, gait and balance. Research also included the assessment of muscle tension, deep sensation, intellectual efficacy and the time as elapsed since the stroke.

Analysis of the obtained results revealed significant changes in patients from Group I. After the rehabilitation cycle, there significant improvement in maintaining balance (Tinetti scale), gait stereotype (Tinetti scale) and ability to change body position (PASS scale) were noted. Hemiparetic gait is characteristic of individuals following ischemic stroke. Its specificity is based on deficits of flexion in the hip joint, excessive proliferation in the knee joint caused by hyperactivity of the gastrocnemius muscle and the position of the foot in the clubfoot position. The gait speed is clearly lower, the step length is asymmetrical, balance is difficult to maintain and there are changes in loading of the lower limbs with a shift of the centre of gravity. In our study, the results obtained in the Tinetti – balance and Tinetti – gait tests, confirm the positive effect of strengthening the trunk muscles on the improvement of motion in the distal parts of the body. After the rehabilitative treatment, significant improvement was noted with an average point difference of 2.27 (balance) and 2.13 (gait). This result confirms the relationship described above, that the increase in stability affects the improvement of mobility, which is confirmed, inter alia, by Junsang et al.[27] and Karthikbabu et al.[28]. These authors have demonstrated the positive effect of deep muscle training on improving balance and gait. Sea Hyun et al.[15] presented an exercises programme increasing the stabilization of the trunk for a period of 12 weeks, each session lasting 30 minutes. These authors assessed the cross-section of the trunk muscles using computer tomography and body balance using the BioRescue platform. They indicated that lateral growth of the muscles and significant improvement in balance took place during the 8th week of exercises. They also determined that the improvement of the analysed variables obtained at a given time was mainly a consequence of the adaptation capabilities of the nervous system. Exercises on unstable surfaces exacerbate compensatory patterns and may contribute to increased muscle tension. This is due to, among others, fear of falling, which causes patients to generate more tension in the peripheral muscles. Taking these conditions into account, the use of the PUM armchair in our research allowed the body to be positioned in the axis and to support its individual parts, which provided the patients with a sense of security and eliminated undesirable muscle tension.

In our research, patients from Group II who performed the standard exercise programme also obtained positive results in both changes in the position of the body (PASS), maintaining balance (Tinetti) and changes in gait pattern (Tinetti). Analysis of these results indicates that the differences were, however, smaller (Tinetti balance by 1.47 points and Tinetti gait by 1.1 points), which is also confirmed by Karthikbabu et al[28]. The presented results confirm that conducting standard exercises also has a beneficial effect on improving the analysed variables and should be part of the rehabilitation programme. Such a state of affairs is of interest also to Mikołajewska[3], Domański et al.[9], Pollock et al.[17], Lance et al.[29] as well as Jarosławska and Błaszczyk[30] who focus on quality of life of these patients. According to Disa et al.[31], increased muscle tension is a very important element of physical disability in people after stroke. Disorders in the distribution of muscle tension in the lower limbs cause abnormal loading and impairment, and thus, affect gait pattern. The insufficiently loaded paretic side results in a significant shift of the centre of gravity, resulting in imbalance. The result of load asymmetry is the lack of integration of pulses reaching the eye, vestibular organ and proprioceptors, causing internal neurosignal disorders. This stance is also presented, among others, by Krukowska[8]. Increased muscle tension leads to impairment of precise movements, at the same time, triggering the formation of co-movements which is an expression of compensation that allows the performance of a specific motor task. According to Głowacka and Krawczyk[32], increased muscular tension mainly concerns the peripheral joints, significantly impairing the motor skills of patients and their performance of basic activities. In this context, Rynkiewicz et al.[33] found significantly lower motor fitness levels in patients after stroke, in which spasticity of the distal muscle groups was accompanied by a decrease in proximal muscle tension.

In our study, muscle tension was assessed using the Ashworth scale. In patients from Group I, there was significant improvement in the elbow, knee and ankle-tibia joints. These results may suggest that proper treatment rehabilitating local muscles improves trunk stability, which has a positive effect on reducing muscle tension of the polyarticular muscles. In patients from Group II, however, there was a slight reduction in muscle tension in the knee and ankle-tibia joints, which also suggests improving their overall fitness. Picelli et al.[34] demonstrated that in adults after ischemic stroke, the degree of paresis is associated with the risk of developing pronounced spasticity. These authors also argue that the proximal part of the upper and distal limbs show greatest sensitivity of its development, which takes place primarily within 6 months after the onset of stroke. Among others, Rykała and Kwolek[5] as well as Czernicki and Woldańska-Okońska[35] referring to the issues in question, confirm the influence of the location (side) of paresis on the effects of treatment. They point out that the treatment of patients with left-sided paresis after ischemic stroke results in worse results than in patients with right-sided paresis. Therefore, it should be assumed that the location of the stroke focal point in the right hemisphere of the brain causes perceptual and motor disorders. Additionally, according to Schaefer et al.[36], the patients' lack of acceptance of their state of health and a significant reduction of motivation to undertake actions aimed at recovery causes the patients with left-sided paresis to receive less satisfactory results of broadly understood improvement. In our study, it was found that in patients with right-sided paresis belonging to Group I, there is a significantly lower difference in the load concerning the two-weight test. In Group II patients, however, no such correlation was noted. Load asymmetry decreased in patients from Group I, which may translate into improved stereotype of their gait and postural control. Schaefer et al.[36] also suggest that the hemispheres of the brain are responsible for the control of various traits in different ways. The authors also hypothesized that damage to the left hemisphere of the brain may cause deficits in the specification of the initial features of the trajectory, while damage to the right hemisphere of the brain results in deficits in the precision of assuming final positions. According to Mikołajewska and Mikołajewski[37], among others, this state of affairs confirms the view that asymmetric deficits in patients after stroke can be associated with various involvement of the left and right hemisphere in the control of the movement of individual limbs. According to Mikołajewska[38], as many as 85% of patients after stroke are diagnosed with sensory disorders of the upper limb, which manifest themselves in the impairment of touch, pain, temperature sensations and proprioception. Being a connector with the external environment of a complex anatomical structure, the hand is responsible, inter alia, for the execution of complex precise movements. In patients after stroke, its functionality is clearly weakened, which obviously translates into limitations in the implementation of self-care activities, and thus, the quality of life of these patients[5]. The characteristic feature of upper limb dysfunction in patients after ischemic stroke is spastic tension that results in the placement of the limb in accordance with spastic pattern. The patient's arm is in adduction and inner rotation, the elbow joint is bent and in pronation, the wrist in flexion, and the hand clenched into a fist. This state is primarily the result of proper tension and the work of ligaments and muscles, which, being inefficient, provoke subluxation of the glenohumeral joint, which is accompanied by various clinical symptoms of pain or shoulder-hand syndrome[39]. According to Mudie et al.[40], the occurrence of these symptoms is associated with the extent and course of stroke and is a prognostic factor for the effects of its treatment.

Based on our own research, it should be assumed that appropriately planned, modified and consistently implemented treatment to improve patients after ischemic stroke is able to significantly reduce sensory disorders of the upper limb. After performing the rehabilitation treatment appropriate for these circumstances, the patients improved the deep sensation assessed on the distal part of the upper limb, and the number of errors decreased by 0.63 in Group I and by 0.5 in Group II. Carlsson et al.[39] showed that people with post-stroke sensory disturbances involving the upper limb control the ineffectiveness of its movements in a different way, which obviously adversely affects the performance of everyday activities. The study participants reported particular difficulties when performing two tasks at the same time. They were mainly difficulties in making smooth movements while maintaining the precision of the grip while lifting certain objects and holding or throwing them. Such circumstances, in turn, generated negative emotions and increased spastic tension in the muscles of the examined limb. Analysing the results of our research based on FRT, PASS, Tinetti and the range of muscle tension, it was found that they were better in patients qualified for Group I. The results of these tests show improvement in dynamic and static balance that make up postural control. They also allow us to assume the stance that the treatment improving patients after stroke directed towards increased activity of the deep muscles is much more advantageous compared to general rehabilitative methods.

In this context, the PUM armchair seems to be particularly useful and effective. It allows arranging the body in one line (axis) while providing support for the spine and limbs and the impulsation frequently required due to neurological state. In addition, the movable seat allows making slight movements in the sagittal as well as frontal plane, and thus, the rotational movements of the body and the dynamic stabilization of the trunk. Such location of particular body parts has a positive effect on improving its stability and biomechanical capabilities[24]. The significance and influence of rotational movements between the upper and lower trunk on mobility and body stabilization, and thus its functional state, are noticed by, among others, Mudie et al.[40] or Dean et al.[41]. According to these authors, the rotational activity of the trunk muscles is not one-sided and requires static stability of contralateral muscles, and learning to maintain the trunk's position may improve the symmetry of the body in patients after a stroke. These authors believe that the better the motor control of the trunk, the greater the improvement of mobility in the area.

The time passed from immediately after ischemic stroke to undertaking therapeutic measures, is an important prognostic indicator of regaining lost motor and intellectual functions. The greatest dynamics of motor changes occur in the early period after the stroke, and in the opinion of Przysady[42] and Kreisel et al.[43], the time to recover motor functions is difficult to determine. The neurobiological mechanism of spontaneous recovery mainly depends on the functional plasticity of the brain and the associated synaptogenesis. The nature and course of these changes usually appear within 3 months of the onset of stroke. According to Diserdens et al.[44], the physiotherapeutic treatments used at this time should take all possible methods of fighting motor dysfunctions into account, thus stimulating regenerative processes. According to Sacco et al.[45], Duncan et al.[46], and Bidzan L. as well as Bidzian M.[47], among others, it is largely decisive of the time and range of returning to the broadly understood efficiency of the treated patients. Analysing these reports with regard to the results of this study, there was a significant difference in Group I patients between the time elapsed since the stroke and the effects of the rehabilitation treatment. All used functional tests confirmed the dependence - the longer time elapsed from ischemic stroke, the worse the treatment results. Also noteworthy is the fact that in Group II patients, there was a different correlation in the 9-hole Peg test – the longer time elapsed from ischemic stroke, the better the results obtained by these patients.

Such characteristics of the results may be primarily caused by the varied level of disability of the respondents. However, no significant dependence of other analysed indicators on the basis of other tests was found. Mood changes, anxiety or depression caused by a stroke are factors that significantly affect the patient's motivation to accept the proposed rehabilitative treatment, including those reflecting changes in their quality of life. These conditions are noticed by, inter alia, Carod-Artal[48], Ziółkowska-Kochan and Pracka[49], Jaracz and Kozubski[50] and others[50,51,52].

The most common affective disorder in people with stroke is depression. It results both from brain dysfunctions caused by metabolic and vascular disorders in its course and from the nature of adaptive reactions of the patient. In these patients, serotonin and norepinephrine levels were found to decrease in the frontal lobes of the brain and in the basal ganglia, and Soares et al.[54] recommend testing the level of anticardiolipin antibodies, especially in patients with systemic diseases. Cognitive impairment in patients after ischemic stroke is conditioned by many factors. One of them is damage to the limbic system, amygdaloid nucleus and prefrontal cortex. According to Carod-Artal[48], any abnormalities in the functioning and mutual cooperation of these structures are the main cause of memory and affective disorders in patients after stroke. The properly operating memory results from the proper functioning of the prefrontal cortex centres, and the emotional significance depends on the cirgulate gyrus. Emotional disorders, on the other hand, result from amygdaloid nucleus functioning. According to the same authors[48], it is difficult to recognize depression in patients after a stroke. This state is primarily due to the simultaneous occurrence of symptoms characteristic both for post-stroke emotional disorders and organic brain damage, but also typical for depression, including psychomotor deceleration. They also found that after stroke, depression was diagnosed in 31% of patients, which occurs within the first three months of the disease. After one year, this number increases to 40%. According to Ziółkowska-Kochan and Pracki[49], during the first six months of the disease, depression is diagnosed in about 46% of those treated for stroke. Problems of emotional disorders in patients after ischemic stroke have also become the subject of interest of the authors' research, considering the gender of the treated patients. For patients in both groups included in the study, however, there was no significant difference in the analysed variables. Such a result may suggest too small diversity of the group of patients or their small number. The lack of dependence between the occurrence of depression and sex in those treated for past stroke is also confirmed by Jiao et al[50], among others. At the same time, these authors deny the occurrence of these disorders depending on the location of the impact centre in the brain, including its hemispheres. They are inclined to conclude that the occurrence of this disease is associated primarily with the extent and severity of post-stroke lesions and with the possible recurrence of stroke. The causes of depression in these patients are also associated with the activity of inflammatory cytokins, IL-6 in particular, whose significant increase in serum levels was observed in this group of patients. The symptoms of depression are also associated with extreme exhaustion of the body and unwillingness to undertake any physical activity. Robinson and Jorge[53], among others, present such a stance, who in this state of the patients after a stroke see fundamental difficulties in getting back to health. They also point out that symptoms of depression and fatigue syndrome often co-exist, and in these circumstances, depression clearly impairs the motor skills of the patients and their cognitive abilities. However, the results of our own studies do not confirm such a position, which may result from the small diversity of the groups of patients included in the study or from their too small numbers. Changes in muscle tension in patients after stroke are also associated with the level of perceived anxiety. Such a stance is presented, among others, by Robinson and Jorge[53] and by Loubinoux et al.[55]. These authors suggest that this state and cognitive impairment may be affected by deficiencies of the neurotrophic factor and serotonin. This translates into executive functions, learning effectiveness and mood changes. Loubinoux et al.[55] also believe that disturbances in neural projection from the midbrain to the brainstem may promote depression and cognitive impairment. In our study, there was a relationship between anxiety level and muscle tension - the higher the recorded level of anxiety, the lower the reduction in muscle tension. On the other hand, no significant correlation between the occurrence of cognitive impairment and the efficacy of the rehabilitative treatment was found in patients from both groups included in the study. Strokes certainly cause severe damage resulting in many types and degrees of functional and emotional disorders in most patients. They significantly affect their motor and intellectual efficiency, and thus, their quality of life. The treatment of these patients is undoubtedly a serious interdisciplinary challenge in which the role of broadly understood rehabilitation seems to be indisputable and even crucial. Perhaps the next step in solving numerous problems related to motor and postural control in patients following stroke in patients from different populations is deep muscle training. Work on the deep muscle structure can be a beneficial form or complementary therapy focused on function. Perhaps also, the PUM armchair used in the presented research will become part of this step.

CONCLUSIONS

1. The improvement of deep muscle activity in patients rehabilitated due to previous ischemic stroke has a beneficial effect on muscular tension, and thus, results in improved balance and postural control.
2. Correct deep muscle activity in patients after ischemic stroke reduces the spastic tone of the peripheral muscles, and thus, affecting functionality of the upper limb.
3. The time from the onset of ischemic stroke to undertaking rehabilitative treatment has significant impact on its final results. The longer this time, the worse the results of treatment.
4. The applied rehabilitation programmes for patients after ischemic stroke in the studied group have positive effects on the re-education of their gait stereotype and the degree of loading the lower limbs.
5. The level of intellectual efficiency of patients rehabilitated due to previous ischemic stroke has no significant effect on the final results of their treatment.

Conflict of interest: None declared

References

1. Goldstein L.B., Bushnell C.D., Adams R.J., Appel L.J., Braun L.T., Chaturvedi S. Guidelines for the primary prevention of stroke. A Guideline for healthcare professionals from the American Heart Association/American Stroke Association. J Am Heart Assoc 2011; 42: 517-584.
2. Członkowska A. Udar mózgu – perspektywa leczenia w Polsce w świetle osiągnięć światowych. Pol Przegl Neurol 2005; 100: 1-7.
3. Mikołajewska E. Fizjoterapia po udarze mózgu. Prakt Fizjot Rehabil 2012; 34: 26-33.
4. Ju-Hyun K., Lim-Kyu L., Jeong-Uk L., Mee -Young K., Seung-Min Y., Hey-Joo J. A pilot study on the effect of functional electrical stimulation of stroke patients in a sitting position on balance and activities of daily living. J Phys Ther Sci 2013; 25: 1097-1101.
5. Rykała J., Kwolek A. Wpływ wybranych czynników na jakość życia oraz stan funkcjonalny pacjentów po udarze mózgu. [Influence of selected factors on the quality of life and the functional state of people after a brain stroke]. Przegl Med Uniw Rzesz 2009; 4: 384-391.
6. Kot-Bryćko K., Pietraszkiewicz F. Psychologia w medycynie. Część 1 – deficyty poznawcze u osób po udarze mózgu. [Psychology in medicine Part 1 – cognitive deficits in patients after stroke]. Med Og Nauk Zdr 2012; 18(4): 340-343.
7. Jung K., Kim Y., Chung Y., Hwang S. Weight-shift training improves trunk control, proprioception and balance in patient with chronic hemiparetic stroke. J Exp Med 2014; 232: 195-199.
8. Krukowska J. Wpływ obciążenia kończyn dolnych na równowagę (stabilność) ciała i sprawność chodu u osób po niedokrwiennym udarze mózgu. Acta Balneol 2009; 51(1): 25-34.
9. Domański E., Wilk-Frańczuk M., Kiebzak W., Śliwiński Z. Wpływ wczesnej rehabilitacji na sprawność motoryczną pacjentów po udarach mózgu - doniesienia wstępne. [The effect of early rehabilitation on locomotor function in post-stroke patients : preliminary report]. Fizjot Pol 2008; 8(1): 83-95.
10. Mraz M., Skolimowska B., Szymańska J., Liwosz A. Przemieszczenie środka ciężkości ciała w pozycji stojącej u osób po udarze mózgu na podstawie badań posturograficznych. [Picture of the shift tendencies of the body gravity centre in standing position, in people after cerebral stroke on the basis of posturographic examinations]. Fizjot 2003; 11(2): 32-38.
11. Barnes M.P. Postępowanie w spastyczności. [The Management of Spasticity]. Farmak Psych Neurol 2005; 3: 241-248.
12. Pinto E.B., Nascimento C., Marinho C., Oliveira M., Castro M., Myllane-Fernandes P., et al. Risk factors associated with falls in adult patients after stroke living in the community; baseline data from a stroke cohort in Brazil. Top Stroke Rehabil 2014; 21(3): 220-227.
13. Lee J.S., Kim T.H., Kim D.H., Shim J.H., Lim J.Y. Effects of selective exercise for the deep abdominal muscles and lumbar stabilization exercise on the thickness of the transversus abdominis and postural maintenance. J Phys Ther Sci 2015; 27: 367-370.
14. Puntumetakul R., Areeudomwong P., Emasith A., Yamauchi J. Effect of 10-week core stabilization exercise training and detraining on pain-related outcomes in patient with clinical lumbar instability. Patient Preference and Adherence 2013; 7: 1189-1199.
15. Sea Hyun Bae, Hong Gyun Lee, Young Eok Kim, Gye Yeop Kim, Hyun Woo Jung, Kyung Yoon Kim. Effects of trunk stabilization exercises on different support surfaces on the cross-sectional area of the trunk muscles and balance ability. J Phy Ther Sci 2013; 3: 362-367.
16. Horst R., Hesse S. Trening strategii motorycznych i PNF. Wydawnictwo Top School 2010: 5-19.
17. Pollock A., Baer G., Langhorne P., Pomeroy V. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke: a systematic review. Clin Rehabil 2007; 21(5): 395-410.
18. Taderko P., Krasuski M., Czech J., Dargiel A., Grawadzka-Jodzis I., Wojciechowska A. Wiarygodność badania objawów klinicznych spastyczności u chorych po urazie rdzenia kręgowego w odcinku szyjnym. Ortop Traumatol Rehab 2007; 6: 467-483. 13.
19. Drużbicki M., Przysada G., Rykała J., Podgórska J., Guzik A., Kołodziej K. Ocena przydatności wybranych skal i metod stosowanych w ocenie chodu i równowagi osób po udarze mózgu. [Evaluation of the effectiveness of selected scales and methods used in the assessment of gait and balance after a cerebral stroke]. Prz Med Uniw Rzesz Inst Leków 2013; 1:21-31.
20. Keh-chung Lin, Li-ling Chuang, Ching-yi Wu, Yu-wei Hsieh, Wan-ying Chang. Responsiveness and validity of three dexterous function measures in stroke rehabilitation. J Rehab Resear Develop 2010; 47: 563-572.
21. Jarosławska B., Błaszczyk B. Jakość życia chorych po przebytym udarze niedokrwiennym mózgu leczonych rejonie szpitala powiatowego. [Quality of life of patients after ischemic stroke treated in hospital area of the administrative unit]. Stud Med 2012; 26(2): 19-29.
22. Augustyniuk K., Pawlak J., Jurczak A., Szkup-Jabłońska M., Stanisławska M., Jasiewicz A., et al. Ocena poziomu lęku u pacjentów hospitalizowanych. [Assessment of the level of anxiety in hospitalized patients]. Fam Med Prim Care Rev 2013; 15(2): 73-75.
23. Kurowska K., Krakowiecka K. Zachowania zdrowotne a umiejscowienie kontroli zdrowia u osób po przebytym udarze mózgu. [Health behaviors and health locus of control in subjects after stroke]. Geriat 2014; 8: 13-21.
24. Szczygieł E., Zielonka K., Mazur T., Mętel S., Golec J. Respiratory chest movement measurement as a chair quality indicator–preliminary observations. J Occup Saf Ergon 2015; 21(2): 207-212.
25. Oliveira C.B., Medeiros I.T., Frota N.F., Greters M.E., Conforto A.B. Balance control in hemiparetic stroke patients: main tools for evaluation. J Rehabil Res Dev 2008; 45: 1215-1226.
26. Karatas M., Cetin N., Bayramoqlu M., Dilek A. Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil 2004; 83: 81-87.
27. Junsang Yoo, Juri Jeong, Wanhee Lee. The effect of trunk stabilization exercise using an unstable surface on the abdominal muscle structure and balance of stroke patients. J Phys Ther Sci 2014; 26: 857-859.
28. Karthikbabu S., Bhamini R., Manikanadan N., John M. Solomon., Chakrapani M., Akshatha Nayak. Role of trunk rehabilitation on trunk control, balance and gait in patients with chronic stroke: a pre-post design. Neurosci Med 2011; 2: 61-67.
29. Lance J.W., Feldman R.G., Young R.R., Koeller C. Spasticity: disorder of motor control. Year Book Medical 1980: 485-494.
30. Jarosławska B., Błaszczyk B. Jakość życia chorych po przebytym udarze niedokrwiennym mózgu leczonych w rejonie szpitala powiatowego. [Quality of life of patients after ischemic stroke treated in hospital area of the administrative unit]. Stud Med 2012; 262: 19-29.
31. Disa K., Sommerfeld-Elsy U.B., Svensson A.K., Widěn-Holmqvist L., von Arbin M. Spasticity after stroke its occurrence and association with motor impairments and activity limitations. Strok 2004; 35: 134-139.
32. Głowacka J., Krawczyk M. Zaburzenia napięcia mięśniowego i ich wpływ na stan funkcjonalny w grupie pacjentów we wczesnym okresie po udarze mózgu. Fizjoter Pol 2005; 51: 48-56.
33. Rynkiewicz M., Rogulska U., Czernicki J. Ocena zmian sprawności funkcjonalnej osób we wczesnym okresie po udarze mózgu. [Evaluation of changes in functional capacity of people in the early period after stroke]. Przgl Med Uniw Rzesz 2011; 2: 325-239.
34. Picelli A., Tamburin S., Dambruoso F., Midiri A., Girardi P., Santamato A, et al. Topical distribution of initial paresis of the limbs to predict clinically relevant spasticity after ischemic stroke: a retrospective cohort study. Eur J Phys Rehabil Med 2013; 49: 1-6.
35. Czernicki J., Woldańska-Okońska M. Wpływ strony niedowładu połowiczego na wyniki rehabilitacji chorych po udarach mózgu. Post Rehabil 1999; 13(1): 63-67.
36. Schaefer S.Y., Haaland K.Y., Sainburg R.L. Ipsilesional motor deficits following stroke reflect hemispheric specializations for movement control. Brain 2007; 130: 2146-2158.
37. Mikołajewska E., Mikołajewski D. Nowoczesne rozwiązania techniczne w usprawnianiu funkcji kończyn górnych. [Modern technical solutions in improving function of upper Extremities]. Ann Acad Med Siles 2012; 66(4): 34-40.
38. Mikołajewska E. Przykład terapii niedowładnej kończyny górnej metodą NDT-Bobath. Prakt Fizjoter Rehabil 2010; 11: 24-28.
39. Carlsson H., Gard H., Brogardh Ch. Upper -limb sensory impairments after stroke: self-reported experiences of daily life and rehabilitation. J Rehabil Med 2017; 49: 1-7.
40. Mudie H.H., Winzeler-Mercy U., Radwan S., Lee L. Training symmetry of weight distribution after stroke: a randomized controlled pilot study comparing task-related reach, Bobath and Feedback Training approaches. Clin Rehabil 2002; 166: 582-592.
41. Dean C.M., Channon E.F., Hall J.M. Sitting training early after stroke improves sitting ability and quality and carries over to standing up but not to walking: a randomized controlled trial. Australian J of Physiot 2007; 53(2): 97-102.
42. Przysada G. Wpływ wybranych czynników na efekty rehabilitacji u chorych po udarze mózgu. Effects of selected factors on the outcome of rehabilitation of post-stroke patients]. Med Rehabil 2007; 11(3): 29-37.
43. Kreisel S.H., Hennerici M.G., Bäzner H. Pathophysiology of stroke rehabilitation: the natural course of clinical recovery, use-dependent plasticity and rehabilitative outcome. Cerebrovasc Dis 2007; 23: 243-255.
44. Diserens K., Michel P., Boguslavsky J. Early mobilization after stroke: review of the literature. Cerebrovasc Dis 2006; 22: 183-190.
45. Sacco R.L., Adams R., Albers G., Benavente O., Furie K., Goldstein L.B., et al. Guidelines for prevention of stroke in patients with ischemic stroke or transient ischemic attack. A statement for the American Academy of Neurology affirms the value of this guideline. Circulation 2006; 113: 409-449.
46. Duncan P.W., Sullivan K.J., Behrman A.L. Azen S.P., Wu S.S., Naseau S.E., et al. Protocol for the locomotor experience applied post-stroke (LEAPS) trial: a randomized controlled trial. Neurol 2007; 7: 39-44.
47. Bidzan L., Bidzan M. Czynniki naczyniowe a progresja zaburzeń funkcji poznawczych w populacji osób w wieku podeszłym. Psych Pol 2005; 36(5): 987-995.
48. Carod-Artal F.J. Post-stroke depression: its differential diag- nosis, complications treatment. Rev Neurol 2006; 42: 328-344.
49. Ziółkowska-Kochan M., Pracka D. Depresja po udarze mózgu. Psychiat w Prakt Ogólnolek 2003; 3(4): 203-208.

50. Jaracz J., Kozubski W. Quality of life in stroke patients. Acta Neurol Scand 2003; 107: 324-329.
51. Jiao J.T., Cheng C., Ma Y.J., Huang J., Dai M.C., Jiang C., et al. Association between inflammatory cytokines and the risk of post-stroke depression and the effect of depression on outcomes of patients with ischemic stroke in a 2-year prospective study. Exp Ther Med 2016; 12: 1591-1598.
52. Mac Intosh B.J., Edwards J.D., Kang M., Cogo-Moreira H., Chen J., Mochizuki G., et al. Post-stroke fatigue and depressive symptoms are differentially related to mobility and cognitive performance. Exp Ther Med 2016; 3: 1591-1598.
53. Robinson R.G., Jorge R.E. Post-stroke depression: a review. Am J Psychiatry 2016; 173: 221-231.
54. Soares M., Morais M.F, Soares J., Pinheiro N., Nunes A.R., Aquiar P. Anticardiolipin antibodies in patients with cerebral vascular accident. Rev Port Cardiol 1998; 17(6): 525-530.
55. Loubinoux I., Kroneenberg G., Endres M., Schumann-Bard P., Freret T., Filipkowski R.K., et al. Post-stroke depression: mechanisms, translation and therapy. J Cell Mol Med 2012; 16: 1961-1969.

Address for correspondence

Elżbieta Szczygieł
Akademia Wychowania Fizycznego im. Bronisława Czecha w Krakowie,
Aleja Jana Pawla II 78, 31-571 Kraków, Poland
e-mail: elzbietasz@gmail.com