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MEASUREMENT OF WALKING IMPAIRMENT RECOVERY AFTER STROKE

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ABSTRACT:

Introduction: One of the most important goals in rehabilitating patients affected by stroke is re-establishing independent movement by activating as many motor patterns as possible and changing existing preexisting abnormal motor patterns

Objective: To determine recovery level with the accent on motor functions recovery in a patient affected by an ischemic stroke for the first time. The study included patients with anterior circulation syndrome, posterior circulation syndrome, and lacunar syndrome in the acute and post-acute phases of physical therapy and rehabilitation.

Material and methods: We conducted a prospective study, which included a total of 90 patients with the first onset of ischemic stroke. The first group consisted of 30 patients with the anterior circulation syndrome of; the second group of 30 patients with the posterior circulation syndrome and the third group of 30 patients with the lacunar syndrome. At the beginning of their early rehabilitation treatment at the Clinic of Physical Medicine and Rehabilitation, the Bamford Scale was used in the initial assessment of the clinical classification of stroke. After the rehabilitation treatment and six months after the stroke, an assessment of motor functions and improvement in overall functionality was performed using a six-minute walk test.

Results: The six-minute walk test in all the studied groups showed significant improvement six months after the stroke compared to testing done immediately after their rehabilitation treatment ($p = 0.01$ anterior circulation, $p = 0.05$ posterior circulation, $p = 0.01$ lacunar syndrome). The six-minute walk test was statistically significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the rehabilitation treatment ($p = 0.005$) and six months after stroke; $p = 0.02$.

Conclusion: The importance of rehabilitation in the acute and post-acute phases of patients with first ischemic stroke is evident. The six-minute walk test in all studied groups showed statistically significant improvement after six months post-stroke period compared to post-rehabilitation testing. The results were statistically significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the physical treatment and the time period of six months after the stroke.
Keywords: Ischemic stroke, walking impairment assessment, rehabilitation, anatomic distribution.

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INTRODUCTION

It was previously believed that injuries of brain tissue caused by stroke are permanent in their nature and that only the brain functions expected to recover were those caused by brain edema. In the last few decades, with the intensive development of neurophysiology, it has been increasingly accepted that there is a process of Central Nervous System - CNS regeneration and re-structuring, so-called neuroplasticity, that ends after 2 years. Numerous studies, although based on experiments done in animals, suggest that early CNS stimulation after the stroke is of particular importance in re-structuring and regeneration. [1] In order to understand after-stroke recovery mechanisms nowadays, it is of utmost importance to identify suitable biomarkers that will enable reliable monitoring of the recovery process in individuals taking part in rehabilitation programs. Reliable biomarkers are also necessary in order to predict treatment outcomes and optimize procedures used during the rehabilitation process. Numerous studies using different experimental models have shown that an ischemic lesion leads to an increase in neural stem cells and subsequently an increase in the generation of new neurons

via compensatory neurogenesis. After the stroke resting microglia activates, changes its phenotype, and from its resting ramified state microglial cells progress into a hyper-ramified state. In animal models with ischemia, exposure to a sensory-enriched environment and exercise has shown a reduced activation of microglia and macrophages, which may be the basis for better functional recovery. [2,3] Such observations may further support the clarification of the molecular basis for the positive effects of early rehabilitative treatment of ischemic brain lesions and better functional recovery compared to individuals not included in early rehabilitation treatment. [4,5]

Restoration of motor functions comes through functional reorganization of the interneuron system, the formation of alternative pathways, collateral branching, and the unmasking of ineffective synapses so-called "unmasking phenomena". The degree of restoration depends primarily on the severity of the CNS lesions whether it is just diaschisis lesions or severe destruction of brain structures. Nowadays imagining techniques provide us with images that give us an objective confirmation of CNS neuroplasticity that comes with intensive rehabilitation [6].

One of the important goals of rehabilitation is to re-establish independent walking. Analyzing the intact nervous system during movement, we can see that the nerve impulses in different combinations are directed towards the limb muscles. Isolated muscle activity is never used during movement, only muscle groups. Patterns of posture and movement in patients with hemiplegia are few and stereotypical. The patient always uses the damaged side of the body in the same way through abnormal motor patterns. The main goal of treatment is to activate as many motor patterns as possible and change the already present abnormal motor patterns. **Objective**: To determine the degree of walking impairment and recovery of movement functions in patients after ischemic stroke with anterior circulation syndrome, posterior circulation syndrome, and lacunar syndrome in the acute and post-acute phases of physical therapy and rehabilitation.

PARTICIPANTS AND METHODS

This was prospective and was conducted at the Department of Neurology and the Department of Physical Medicine and Rehabilitation, during a two-year period. The study included a total of 90 consecutive patients who suffered an ischemic stroke. The first group consisted of 30 patients with anterior circulation syndrome; the second group of 30 patients with the posterior circulation syndrome and the third group of 30 patients with the lacunar syndrome. Patients who have been in a coma for more than 48 hours, as well as hemodynamically unstable patients, were not included in the study. Other exclusion factors were hemorrhagic stroke, recurrent strokes, patients who have been treated with thrombolytic therapy, and patients with aphasic disorders. In addition to medical history and clinical examination, the diagnosis of stroke was confirmed by the results of computer tomography CT and /or nuclear magnetic resonance NMR imaging of the brain. Patients were included in early rehabilitation treatment immediately after stabilization of their vital functions with continuous monitoring of blood pressure, pulse, and respiration. After the patients were discharged from the Department of Neurology, they were transferred to the Department of Physical Medicine and Rehabilitation where stationary rehabilitative treatment was conducted for up to 8 weeks. Retesting of the patients was performed 6 months after the stroke. All the patients, during the planning and early rehabilitative treatment in the Department of Neurology and the Department of Physical Medicine and Rehabilitation, received individual exercise programs, with appropriate introductory electrotherapy and thermo procedures. Patients also received somathopedical treatment with the training of motor and cognitive functions, as well as self-care activities. Bamford scale was used for clinical stroke classification [7].

This scale represents the clinical-topographic classification of ischemic stroke and is divided into Total anterior circulatory infarction (TACS); Anterior circulatory partial infarction (PACS); Posterior circulation infarction (POCS) and Lacunar infarction (LACS). After the rehabilitation treatment was conducted and six months after the stroke, an assessment of movement and progress in overall functionality and level of physical readiness was performed using a six-minute walk test [8]. More than one method can be used to assess the walking time. It can either be walking speed on a particular route or endurance that is analyzed. As part of the endurance test, two-minute, six-minute, and twelve-minute walks are monitored. Basically, the patient is asked to walk at the speed that suits him best, on a predetermined route, usually up to 20 m on his own or with any kind of help (including assistance) until the moment he is told to stop. The patient is also instructed to stop walking at any time if he feels unable to complete the test. The optimal testing time is six-minutes. The total distance reached during the test is being recorded.

RESULTS

Ambulance evaluation movement and increase in overall physical reediness were analyzed using a six-minute walk test for all groups. In the group of patients with the anterior circulation syndrome, the value of the score of a six-minute walk ranged from 20 to 400 m after physical treatment, averaging 126 (SD +87.70). Six months after stroke, the value of the six-minute walk score in the group of patients with anterior circulation syndrome ranged from 30 to 450m, averaging 199.66 (SD +129.80). In the group of patients with posterior circulation syndrome, the value of the six-minute walk score ranged from 20 to 225 m after physical treatment, averaging 98.33 (SD +59.96). Six months after stroke, the value of the six-minute walk score in the group of patients with posterior circulation syndrome ranged

from 40 to 400 m, averaging 157 (SD +95.10). In the group of patients with the lacunar syndrome, the value of the six-minute walk ranged from 20 to 400 m after physical treatment, averaging 153.33 (SD +84.68). Six months after stroke, the value of the six-minute walk score in the group of patients with posterior circulation syndrome ranged from 30 to 500 m, averaging 219 (SD +118.85) (Table 1).

Table 1. Assessment scale of a 6-minute walk test after rehabilitation treatment and six months after the stroke

Group of patients	6 minutes walk test after therehabilitation treatment	6 minutes walk test six months after the stroke	p
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80	0.01
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10	0.005
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85	0.01

p=statistical significance

We obtained the following results (shown in Tables 2,3 and 4) comparing the score values of the six-minute walk test between the cohorts.

Table 2. Assessment scale of 6-minute walk test in groups of participants with the anterior syndrome and posterior circulation syndrome

Group of participants	6 minutes walk test after the physical treatment	6 minutes walk test 6 months after the stroke
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10
p	0.15	0.15

p=statistical significance

Comparing the assessment score of the six-minute walk between the group of participants with anterior circulation syndrome and participants with the syndrome of the posterior circulation, no statistically significant difference was found between these groups. The difference was not statistically significant after physical treatment performed during treatment at the Department of Physical Medicine and Rehabilitation nor after six months of stroke (p = 0.15 after physical treatment; p=0.15 six months after stroke).

Table 3. 6-minute walk test assessment scale in groups of participants with anterior circulation syndrome and lacunar syndrome

Group of participants	6minutes walk test after the physical treatment	6minutes walk test six months after the stroke
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85
p	0.2	0.5

p=statistical significance

Comparing the assessment score of the six-minute walk between the group of participants with anterior circulation syndrome and the participants with the lacunar syndrome, no statistically significant difference was found between the mentioned groups. Although the score was slightly better in participants with the lacunar syndrome, the difference was not statistically significant either after rehabilitation treatment performed during treatment at the Department of Physical Medicine and Rehabilitation or six months after the stroke (p = 0.2 after rehabilitation treatment;p=0.5 six months after the stroke).

Table 4. 6-minute walk test assessment scale in groups of participants with posterior circulation syndrome and lacunar syndrome

Group of participants	6minutes walk test after the rehabilitation treatment	6minutes walk test 6 months after the stroke
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85
p	0.005	0.02

p=statistical significance

If we compare the score of the six-minute walk assessment test between the group of participants with posterior circulation syndrome and lacunar syndrome, participants with the lacunar syndrome have a statistically significantly better score compared to the participants with posterior circulation syndrome. The difference was statistically significant after rehabilitation treatment received at the Department of Physical Medicine and Rehabilitation as well as six months after the stroke (p = 0.005 after physical treatment; p = 0.02 six months after the stroke).

Figure 1. Six-minute walk assessment scale after the rehabilitation treatment

As it can be seen from the graph above, participants with posterior circulation syndrome after the rehabilitation treatment had a score lower than 300 m, in contrast to participants with the lacunar syndrome who had a significantly higher score, and over 400 m (Figure 1).

Figure 2. Six-minute walk assessment test scale six months after the stroke

As it can be seen from the graph above, participants with posterior circulation syndrome six months after the stroke had a slightly better score that was lower than 400 m, but the score of these participants was statistically significantly lower than the score of participants with the lacunar syndrome.

DISCUSSION

In all tested groups, the six-minute walk score used for motility and assessment of overall physical reediness was statistically significantly better six months after the stroke compared to the score obtained immediately after the physical treatment (in the group of participants with anterior circulation syndrome p = 0.01, with posterior circulation syndrome p = 0.005, with lacunar syndrome p = 0.01). In the individual comparison of a six-minute walk between groups, participants with the lacunar syndrome had a statistically significantly better score compared to participants with posterior circulation syndrome (p = 0.005 after physical treatment; p = 0.02 six months after stroke). One of the important goals is to re-establish independent walking. In the early phase of recovery or if recovery is limited to the weak synergistic activity, walking will not be possible for several reasons. These are poor postural control of the torso in a standing position, inability to achieve stable standing on the affected leg during walking in the supported phase, and inability to initiate leg movement (selective movement) in the hip during walking in the phase of leg movement. In an immobile stroke at the beginning of kinesiotherapy, it is necessary to obtain and develop maximum torso control and introduce the exercises necessary to prepare the patient for walking such as posture, balance, weight transfer to the hemiplegic leg. As recovery progresses, the patient establishes better motor control, and torso balance and improves muscle strength in the affected paretic leg. Walking improves as selective physical activity of walking muscles is established during motor recovery. The patient should be specially instructed on how to position the body, as there is a tendency to lean on the affected side. Due to the disturbed kinesthetic information about the position of the body, a mirror is used for the purpose of vision correction. In the lower extremities, the axial muscle chain is strengthened, which serves as a stabilizer of the upright posture; m. gluteus maximus and m. quadriceps femoris [9].

Several studies indicate that patients with hemiparesis benefit from the use of a treadmill during intensive walking exercise in kinesiotherapy with partial stability of the torso and pelvis with straps around the torso and pelvis, as help and safety from falling due to torso instability. Initially, the patient needs the help of one or more therapists to control the torso, pelvis, and weak legs. Walking exercises on the treadmill have proven to be more successful in walking recovery than conventional kinesiotherapy. It has been proven that with the training of walking on the treadmill, patients in outpatient rehabilitation, as well as those who have already walked, significantly improve their walking speed [10,11]. A clinical study from Gothenburg conducted the year 2011 encountered 96 patients with the first time ischemic stroke, with the aim of assessing the risk of falls during the first year after the stroke. The authors state that 48% of patients had at least one fall during the first year. The predictive value of tests examining postural balance, walk quality, and motor ability was assessed. The study used Motor Assessment Scale-MAS a 10-meter walking test, a „time-up and go "test, and the Berg balance scale. All tests are associated with a risk of falls. The 10-Meter Walk Test-MWT had the highest predictive value. Participants that were unable to conduct 10 MWT during the first week after the stroke had a statistically significantly higher risk of falling (p <0.001). Clinical trials used during the first week after the stroke may to some extent identify those patients at risk of falling during the first year after stroke [12]. A study by Bijleveld-Uitman, van de Port and Kwakkela [13] analyzes whether walking speed or crossing a certain distance is a better indicator of movement function compared to daily walking or walking. A 5-meter walk and a 6-minute walk were tested, where speed and length of walking were measured. The study shows that the measurements of walking speed as well as crossing a certain distance are equally accurate and that both methods of measurement are strongly related to the results of daily walking with an accuracy in the range of 77-85%. A study by Ho-Jung et al. [14] analyzed the effects of different training methods with the double task of walking with balance and walking of patients with chronic stroke. A 10-meter and a six -minute walk test were used. In the first group, motor training with walk training was done, in the second cognitive training with walk training, and in the

third group motor and cognitive training with walk training. The results showed that the group with comparative motor and cognitive training showed the greatest progress. Namely, this training is more effective in improving the balance and quality of walking, than individual training of motor skills and walking or cognition and walking. The research emphasized the role of recognition and concentration during the dual task of holding and controlling during the walk as a paradigm of motor learning. The authors state that patients need to perform motor tasks and high cognitive function at the same time, as we do during daily activities when we perform several tasks at the same time. A similar study addresses the problems of post-stroke patients who show a reduced ability to perform multiple tasks simultaneously while exercising walking function. Conventional rehabilitation does not sufficiently address this problem which can contribute to low levels of functioning and physical inactivity. The effectiveness of dual walk training tasks a year after stroke was analyzed. The effects of walking with motor and cognitive impairments during comfortable walking speed, during overcoming obstacles and during spontaneous physical activity were compared. A positive outcome was shown in performance and cognition during the unhindered walking. Also, the secondary outcome is the spatiotemporal and kinetic parameters of the walk. This study suggests that physicians should decide on the types of rehabilitation activities to improve the performance of dual tasks after a stroke [14]. It is important to choose tests that assess the motor recovery of the lower extremities during the acute phase of a stroke with the use of early rehabilitation treatment. There are few guidelines that suggest to clinicians the most optimal choice during the inpatient phase of treatment. A 2014 cohort study evaluated the effects of applying the 10-meter walk test, the MAS, and the Step Test. The results show that the largest changes in discharge parameters were recorded in the part of the MAS that evaluates mobility, in 44% of patients. Other tests used also showed significant changes in motor recovery, but the MAS result related to mobility showed the largest changes [15, 16]. A study by Selves at all. analyzes review of the evidence of predictors, clinical outcomes and timing for interventions. Trunk control and lower limb motor control (e.g. hip extensor muscle force) seem to be the best predictors of gait recovery in clinical practice at 1 week post-stroke. In terms of walking performance, the 6-min walking test is the best predictor of community ambulation [17]. A study by Rose, Nadeau et al. analyses the effect of the number of exercise training sessions on recovery of walking ability after stroke. Participants at 2 and 6 months after stroke gained in gait speed and walking endurance after up to 36 sessions of treatment, but the rate of gain diminished steadily and, on average, was very low during the 25- to 36-session epoch, regardless of treatment type or severity of impairment. The tracking of individual response trajectories is imperative in planning treatment [18].

CONCLUSION

The importance of rehabilitation in the acute and post-acute phases in patients with the first time ischemic stroke is evident. The six-minute walk test score in all examined groups was statistically significantly better six months after the stroke compared to the test conducted immediately after the rehabilitation treatment. The results are statistically significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the rehabilitation treatment and six months after the stroke. A 6-min walking test is a practical tool for the assessment of motor functions and improvement in overall functionality after a stroke.

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