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## **The effectiveness of PNF method in rehabilitation of patients after ischemic stroke**

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## SUMMARY

**Introduction.** Stroke is a major medical and social problem. One of the methods used in neurodevelopmental rehabilitation of patients after ischemic stroke is the method of Proprioceptive Neuromuscular Facilitation (PNF).

**Objective of the work.** Evaluation of effectiveness of PNF method in rehabilitation of patients after ischemic stroke.

**Material and methods.** The study included 100 patients with ischemic stroke. In the study group (A) an individual rehabilitation program included the rehabilitation of the classical method and PNF, in the control group (B) of the patients were only streamlines the traditional individual rehabilitation. Degree of disability was evaluated on the basis of the modified Rankin scale, the level of movement disorders examined scale Brunnström. To assess the functional status of the patients was used functional indicator "Repty" and modified the RMA.

**Results.** After the rehabilitation method of PNF, an improvement in mobility upper and lower limb in more than 60% of patients was observed. The degree of disability decreased in 40% of patients. There has been improvement in overall motor performance of 25.57% and greater independence in performing activities of daily living of 15.94%.

**Conclusions.** Rehabilitation method of PNF is effective in patients after ischemic stroke; however, this method is not more efficient than conventional physiotherapy. Traditional physiotherapy cannot be excluded from effective methods of rehabilitation of patients after ischemic stroke.

**Keywords:** Ischemic stroke, rehabilitation, PNF method, classical physiotherapy

## INTRODUCTION

Stroke is a clinical syndrome caused by focal or generalized brain damage that persists for more than 24 hours or leading to death, and there is no cause other than vascular. This constitutes a significant medical problem, social and economic, leading to physical disability and dementia, epilepsy and depression. The consequence of a stroke is a reduction in the quality of life of patients [1-4].

Rehabilitation is a form of therapy in stroke. Early initiation of rehabilitation reduces the risk of extra cerebral complications associated with immobilization of the patient. It has been shown that it reduces mortality in the early post-stroke and increases the independence of the patient [5-7].

Proprioceptive Neuromuscular Facilitation (PNF) is a method of physical therapy based on the neurophysiological substrate. The basic premise of this method is pioneering the proper neuromuscular stimulation through the use of neurophysiological rules and the resulting methods for controlled, additional stimulation of the sensory-motor through conduction and proprioceptive stimuli. In the design method is based on the movements of global, consistent with the nature and daily work. Learning technique uses coordination, stabilizers, stretching, improving functions of vegetative and analgesic techniques. Through its variety of techniques used in the method PNF allow not only the use of appropriate movement patterns for each patient on an individual basis, they also facilitate the implementation of a particular therapeutic purpose (improvement of strength, mobility, coordination, stabilization). The choice of technique depends on the individual needs of the patient and its functional problems. PNF techniques provide a treatment option for patients with almost all mobility problems. Proposition stroke rehabilitation concept of PNF techniques can be improve, which include movement patterns upper and lower limbs, techniques agonists and antagonists, exercises using gum Thera-band, work in the open and closed chain, stable and unstable [8-10].

## **OBJECTIVE OF THE WORK**

The aim of the study was to evaluate the effectiveness of PNF method in rehabilitation of patients after ischemic stroke. Formulated the following specific issues:

1. Do exercises using assumptions PNF method to minimize the degree of movement disorders examined in the upper limb and lower limb,
2. To what extent the rehabilitation of the PNF method affects the functional status of patients with ischemic stroke.

## **2. MATERIAL AND METHODS**

The study received a positive opinion of the Bioethics Committee of the Medical University of Lublin (No. approval: EC 0254/37/2012).

The study involved 100 people, including 49 women and 51 men, aged from 24 to 87 years. All had been diagnosed with ischemic stroke and underwent comprehensive treatment in rehabilitation departments in medical facilities Lublin province. During the 21 days of rehabilitation, subjects were systematically streamlining five days a week (Monday-Friday) 1.5 - 2 hours a day, on Saturday - about 50 minutes.

All persons participating in the study were divided into two groups. In group A - test (50 people) was used the individual traditional physiotherapy and method of PNF. In group B - control (50 people) rehabilitation was based on individual traditional physiotherapy.

Additionally, patients of both groups were using the procedures in the field of physical therapy.

Criteria for selection of groups:

- Diagnosed with ischemic stroke,
- Informed consent to participate in research,
- Improvement using PNF or traditional physiotherapy,
- Systematic rehabilitation for at least 21 days,
- Double-patient study before and after 3 weeks of rehabilitation,
- Behavior logical verbal contact with a therapist.

Traditional rehabilitation program included:

1. Kinesitherapy individual (passive exercises upper and lower limb covered by paresis, exercise step-passive and active of the upper and lower limb, exercises the same assisted, exercises in relieving upper and lower limb, exercise free active, vertical position active exercises on a rotor upper and lower limb, breathing exercises, education or improving gait, balance exercises and coordination).
2. Physical therapy (laser therapy, local cryotherapy, phototherapy, ultrasound, hydrotherapy),
3. Classical massage upper and lower limbs.

Exercise and treatments were selected according to the functional status of the individual and the needs of patients.

Physiotherapy using elements of the concept of PNF was carried out individually and adapted to the current capabilities and needs of patients. Regimen consisted of the following: the starting position, the main principles, techniques, movement patterns.

Depending on the patient's level of functioning introduced, among other things:

- stabilize the standing position with the help of technology: approximation on the ridge of the iliac,
- stabilization of the seated by stabilizing the condenser,
- a combination of movement patterns, which will prepare the patient to alternate work shoulder and pelvic girdle used during gait,
- learning weight transfer body in various positions,
- learning walk on flat terrain, obstacles and stairs.

A study of patients was performed twice: before improvement and after its completion. The survey was carried out starting on the first day of admission to the rehabilitation unit, while the final examination 21 days after the stationary rehabilitation.

Used in the study:

1. Modified Rankin Scale,
2. Brunnström scale - hand and upper limb and lower limb,
3. Rivermead motor assessment - global functions,
4. Functional index Repty (WFR).

Statistical analysis was performed using the statistical package R, version 3.3.1. The analysis of the quantitative variables was performed by calculating the average, standard deviation, median, quartiles, maximum and minimum. The following statistical tests were used: chi-square test, Fisher's exact test, Student's t test, Mann-Whitney test, ANOVA, Kruskal-Wallis test, Tukey HSD test, Dunn, Pearson's correlation coefficient or Spearman. The level of statistically significant was  $p < 0.05$ .

## RESULTS

Group A (test) consisted of 50 patients, including 28 women (56%) and 22 men (44%). Group B (control) consisted of 50 patients; 21 women (42%) and 29 men (58%). Patients from Groups A and B do not differ statistically significant gender ( $P > 0.05$ ).

The average age of the patients was 68.27 years (24-87 years). Patients in Groups A and B did not differ significantly age ( $p > 0.05$ ).

A majority of both groups had paralysis / paresis of the left-hand (68%), right-sided paralysis / paresis occurred in 32% of patients ( $p > 0.05$ ).

Patients in Groups A and B differed significantly from the time of the last stroke to the start of rehabilitation ( $p < 0.05$ ). In group A patients were rehabilitated after a long lapse of time since the stroke. The largest group (38%) patients were 1 to 3 months after stroke, and 1 month after stroke (24%). Over 1 year after the onset of stroke, the rehabilitation of patients was 18%. Group B consisted mainly (78%) patients 1 month after falling ill, 10% are in the range from 1 to 3 months after the stroke, more than one year from the occurrence of the disease was only 6% of respondents.

With comorbidities hypertension and atrial fibrillation occurred more frequently in group B.

Patients in Groups A and B differed statistically significant results on a scale Brunnström for upper limb before rehabilitation. Patients in group A demonstrated a higher mobility of the upper arm and hand at baseline than patients of group B (Table 1).

Table 1. Scale Brunnström - upper limb (before the rehabilitation).

Scale Brunnström - upper limb (before the rehabilitation)	Group A		Group B		Together		p *
	n	%	n	%	n	%	
1	7	14%	13	26%	20	20%	p <0.001
2	24	48%	24	48%	48	48%	
3	5	10%	13	26%	18	18%	
4	0	0%	0	0%	0	0%	
5	10	20%	0	0%	10	10%	
6	4	8%	0	0%	4	4%	

\* Fisher's exact test

Patients in Groups A and B differed significantly Brunnström scale results in lower limb before the rehabilitation. In group A patients were higher (mainly 4 and 5 points), which means better mobility of the lower limb than patients from group B, where the rated efficiency mainly in points 4 and 3 (Table 2).

Table 2. Scale Brunnström - lower limb (before rehabilitation).

Brunnström scale - lower limb (before the rehabilitation)	Group A		Group B		Together		p *
	n	%	n	%	n	%	
1	0	0%	4	8%	4	4%	p = 0.008
2	5	10%	4	8%	9	9%	
3	4	8%	15	30%	19	19%	
4	31	62%	21	42%	52	52%	
5	8	16%	6	12%	14	14%	
6	2	4%	0	0%	2	2%	

\* Fisher's exact test

The results of both groups (scale Brunnström - upper limb) before and after the rehabilitation shown in Table 3.

Table 3. Results of Scale Brunnström - upper limb (after rehabilitation).

Scale Brunnström - upper limb	Group A before rehabilitation		Group A after rehabilitation		Group B before rehabilitation		Group B after rehabilitation	
	n	%	n	%	n	%	n	%
1	7	14%	0	0%	13	26%	5	10%
2	24	48%	12	24%	24	48%	14	28%
3	5	10%	14	28%	13	26%	24	48%
4	0	0%	4	8%	0	0%	7	14%
5	10	20%	8	16%	0	0%	0	0%
6	4	8%	12	24%	0	0%	0	0%

Patients in Groups A and B did not differ significantly improving incidence of upper limb mobility scale Brunnström. In both groups, the improvement was more than 60% of subjects (Table 4).

Table 4. Improvement of motor disorders of the upper limb scale Brunnström.

Scale Brunnström - upper limb	Group A		Group B		p *
	N	%	n	%	
Improvement	32	64%	31	62%	p = 1
No improvement	18	36%	19	38%	

\* Chi-square test

The results of both groups before and after the rehabilitation is presented in Table 5.

Table 5. Results Scale Brunnström - lower limb (after rehabilitation).

Brunnström scale – lower limb	Group A before rehabilitation		Group A after rehabilitation		Group B before rehabilitation		Group B after rehabilitation	
	n	%	n	%	n	%	n	%
1	0	0%	0	0%	4	8%	2	4%
2	5	10%	1	2%	4	8%	4	8%
3	4	8%	0	0%	15	30%	0	0%
4	31	62%	21	42%	21	42%	32	64%
5	8	16%	20	40%	6	12%	10	20%
6	2	4%	8	16%	0	0%	2	4%

Patients in Groups A and B did not differ significantly improve mobility occurrence of the lower limb scale Brunnström. Improvement in the A group was slightly higher (60%) than in group B (54%) (Table 6).

Table 6. Improvement of lower limb motor disorders Brunnström scale.

Brunnström scale - lower limb	Group A		Group B		p *
	N	%	n	%	
Improvement	30	60%	27	54%	p = 0.686
No improvement	20	40%	23	46%	

\* Chi-square test

Patients in Groups A and B differed statistically significant results in the Rankin scale before the rehabilitation. In Group A patients had a lesser degree of disability (mainly breakpoint moderate disability, 3), and in the group B as many as 62% of patients presented severe disability - 5 points (Table 7).



Table 7. Rankin Scale (before the rehabilitation).

Rankin scale (before the rehabilitation)	Group A		Group B		Together		p *
	n	%	n	%	n	%	
1	4	8%	0	0%	4	4%	p <0.001
2	6	12%	2	4%	8	8%	
3	18	36%	10	20%	28	28%	
4	12	24%	7	14%	19	19%	
5	10	20%	31	62%	41	41%	

\* Fisher's exact test

The results of both groups before and after the rehabilitation Rankin scale shown in Table 8.

Table 8. Results of the respondents in the Rankin scale rehabilitation.

Rankin scale	Group A before rehabilitation		Group A after rehabilitation		Group B before rehabilitation		Group B after rehabilitation	
	n	%	n	%	n	%	n	%
1	4	8%	12	24%	0	0%	0	0%
2	6	12%	0	0%	2	4%	6	12%
3	18	36%	24	48%	10	20%	10	20%
4	12	24%	10	20%	7	14%	21	42%
5	10	20%	4	8%	31	62%	13	26%

Patients from groups A and B do not differ statistically significantly greater improvement in the overall operation of the Rankin scale. The degree of disability studied decreased in both

groups. Improvement was observed in approximately 40% of patients (Table 9).

Table 9. Reduction of the degree of disability in patients Rankin Scale after rehabilitation.

Rankin scale	Group A		Group B		p *
	n	%	n	%	
Improvement	20	40%	22	44%	p = 0.839
No improvement	30	60%	28	56%	

\* Chi-square test

The results of the RMA on a scale of respondents are presented in Table 10.

Table 10. The results of the RMA on a scale of respondents after rehabilitation.

Group	RMA							
	N	Average	SD	Median	min	max	Q1	Q3
Group A – before rehabilitation	50	7.9	3.89	9	0	12	6	11.75
Group A – after rehabilitation	50	9.92	3.13	10	3	15	9	12
Group B – before rehabilitation	50	4.5	4.19	4	0	13	1	8
Group B – after rehabilitation	50	7.62	3.2	8	3	13	5	9

Patients in Groups A and B differed significantly resulting improvement in motor deficits in a modified scale RMA. In group B reported a greater improvement in overall motor performance. Patients in group A at baseline had a greater mobility and showed a lesser degree of disability, because some simple steps in a motor test performed already in the first study. Comparing the degree of improvement in motor performance tested after the rehabilitation in group A has been shown that the improvement is not as visible as in group B (Table 11).

Table 11. Improved motor deficits of respondents on a scale RMA after rehabilitation.

Group	RMA - improvement								p *
	N	Average	SD	Median	min	max	Q1	Q3	
Group A	50	2.02	2.02	2	0	8	1	3	p = 0.017
Group B	50	3.12	2.44	3	0	9	1	5	

\* Mann-Whitney test

Improve the value of the individual functions after rehabilitation in both groups are shown in Table 12.

Table 12. The percent improvement of various functions of the WFR.

FUNCTION	WFR - improvement%		p *
	Group A	Group B	
Meals	40	54	p = 0.229
The attention to appearance and personal hygiene	46	40	p = 0.686
Bath	34	38	p = 0.835
Dressing the upper body	36	40	p = 0.837
Dress lower body	18	48	p = 0.003
Toilet	22	32	p = 0.368
Urination	18	28	p = 0.342
Bowel movements	20	28	p = 0.482
Going from the bed or chair to a wheelchair	44	50	p = 0.689
Sitting on the toilet bowl	46	58	p = 0.317
Entering into the shower or bath	46	34	p = 0.307

Walking / riding in a wheelchair	48	72	p = 0.025
Stairs	32	20	p = 0.254
Understanding auditory or visual	4	2	p = 1
Verbal speech	0	4	p = 0.495

The results obtained in both groups before and after rehabilitation, after summarizing the whole WFR are presented in Table 13.

Table 13. Results of the assessment of activities of daily living by WFR.

Group	Functional Indicator "Repty" - Sum							
	N	Average	SD	Median	min	max	Q1	Q3
Group A – before rehabilitation	50	64.24	23.09	60	27	103	47	83
Group A – after rehabilitation	50	74.48	22.71	70	33	105	63.5	99
Group B – before rehabilitation	50	52.4	20.67	45	29	93	35.5	63
Group B – after rehabilitation	50	64.84	19.04	59	35	101	51	80.5

Patients in Groups A and B did not differ significantly improve the size of the result (Table 14).

Table 14. The improvement obtained by the subjects in everyday activities by WFR.

Group	WFR - Total - improvement								p *
	N	Average	SD	Median	min	max	Q1	Q3	
Group A	50	10.24	7.97	10	0	28	4	15.5	p = 0.148
Group B	50	12.44	8.36	12	0	36	4.5	18	

\* Mann-Whitney test

A group of age significantly affects the improvement in the Rankin Scale ( $p < 0.05$ ). This relationship is negative. The older the age, the less improvement. Other correlation coefficients are statistically insignificant ( $p > 0.05$ ), and so the effects of rehabilitation in other scales do not depend significantly on age.

In Group B, the age affects significantly to improving the scale Brunnström for upper limb ( $p < 0.05$ ). This relationship is negative. The older the age, the less improvement. Other correlation coefficients are statistically insignificant ( $p > 0.05$ ), and so the effects of rehabilitation in other scales do not depend significantly on age.

To improve the functioning of the tested scales: Brunnström - lower limb, RMA and Repty depend on the time elapsed since the last stroke to begin rehabilitation ( $p < 0.05$ ). In people with the interval of 1-3 months of improvement in the Brunnström (lower limb) is greater than that of people who this time was less than 1 month and, in them, in turn, is greater than in those in whom the time was above 3 months. Persons within the period up to 1 month and from 1- 3 months had the same results on a scale RMA and they were higher than in the range of more than 3 months. The scale Repty biggest improvement was achieved in patients in whom it was a time for 1 month, then 1-3 months, the smallest improvement was observed in the group of more than 3 months.

## DISCUSSION

Ischemic stroke causes movement disorders in the form of paresis or paralysis of the limbs. Damage may occur also in the field of cranial nerve and includes higher nervous functions [11].

Seniów et al. [12] describe the need for a comprehensive rehabilitation of patients after stroke. Very good results in improving motor describe Zhu et al. [13], who used repetitive transcranial magnetic stimulation in rehabilitation of motor function. Increasing it causes motor function improvement in activities of daily living patients. Rahman et al. [14] conducted a study of stroke patients with paresis of the upper limb, using a robot called Mars-5. The robot facilitates rehabilitation of the shoulder girdle, elbow and forearm for support of movements. The test results show improved precision and accuracy of the tasks performed by the patient.

According to Jankowska et al. [15] of stroke patients in the hospital rehabilitated scored significantly greater improvement than those using environmental rehabilitation. Passive motion used in traditional rehabilitation is performed in one plane in contrast to the practice used in the method of PNF, where the motor pattern is guided in inclined planes. Passive movement is often the cause of iatrogenic complications, especially in patients with flaccid paresis of the upper extremity. Passive motion is one of the possible techniques for use in patients with pain in the complex shoulder joint. The treatment program is recommended, however, selected on the basis of subjective testing, and analysis of the priorities. Warns against movements of large amplitude, as they may exacerbate the condition as a result of tissue compression. The proposed movements are of small amplitude, conducted carefully and slowly, to the border of pain. These observations are supported by a Pop [16].

Domanski et al. [17] evaluating the impact on early rehabilitation efficiency of the motor stroke patients, show a clear improvement in mobility determined gait pattern and functional status muscles. Data from the literature are consistent with its own research, which confirmed a significant impact as soon as possible begun rehabilitation on improving the functioning of patients after ischemic stroke.

Pop et al. [18] examining the factors affecting the symmetry of the loading of the lower limbs and balance in stroke patients found no statistically significant effect on gait side paralysis patients. They observed, however, that people with right-sided hemiparesis achieved worse results than patients with left-sided hemiparesis. The difference demonstrated by the paths takes the foot pressure center on the platform.

Extensive literature characterizing the effectiveness of PNF method in the rehabilitation of stroke patients shows great interest in the above topic. Many studies have shown encouraging results using the PNF method, particularly with regard to increasing the range of motion and improve muscle function [19-23]. Wolny et al. [24-28] published a large number of studies on the impact of the PNF method of rehabilitation of patients after stroke, taking into account the

various aspects of life of patients and improve. The study demonstrates significantly greater effectiveness the methods of PNF than only the application of traditional methods. Krukowska et al. [29] have demonstrated the beneficial effect of the method of PNF and NDT-Bobath in stroke patients.

Own studies did not confirm statistically significant greater efficiency in the use of PNF method than using only classical physiotherapy. According to the inter-group showed a significant differences between groups were measured. Perhaps this is the reason for obtaining the reverse-than-expected results. The results obtained show that, even before the start of the rehabilitation of patients in the study group (using the method of PNF) has a higher mobility and disability lower than the control group (only rehabilitated traditional physiotherapy). A higher number of respondents moved alone, than in the control group, where patients often have used wheelchairs. As a result of this situation, despite the high level of functioning patients in the treatment group, comparing the level of improvement in mobility and the effects obtained after rehabilitation, the study group obtained poorer results in some tests. In addition, patients in the group A were rehabilitated after a long lapse of time from stroke than in the comparison group.

Further research and introduction of new methods of rehabilitation in this ever-growing group of patients can bring progress, improving the health of people after a stroke, and thus tangible benefits for society as a whole [30].

## **CONCLUSIONS**

1. Rehabilitation method of PNF is an effective method of rehabilitation after ischemic stroke.
2. Rehabilitation using the concept of PNF not proved to be more effective in improving patients after ischemic stroke compared with conventional physiotherapy.
3. The study confirmed that using only traditional rehabilitation does not exclude it from effective methods of rehabilitation of patients after ischemic stroke.
4. It has been shown statistically significant correlation between the degree of improvement of the functioning of patients with ischemic stroke, and patients' age and the time of onset of stroke and the start of rehabilitation.

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