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The influence of NDT-Bobath and PNF methods on the field support and total path length measure foot pressure (COP) in patients after stroke

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ABSTRACT

In stroke patients, the NDT – (Bobath – Neurodevelopmental Treatment) and PNF (Proprioceptive Neuromuscular Facilitation) methods are used to achieve the main objective of rehabilitation, which aims at the restoration of maximum patient independence in the shortest possible period of time (especially the balance of the body).

The aim of the study is to evaluate the effect of the NDT-Bobath and PNF methods on the field support and total path length measure foot pressure (COP) in patients after stroke.

The study included 72 patients aged from 20 to 69 years after ischemic stroke with Hemiparesis. The patients were divided into 4 groups by a simple randomization. The criteria for this division were: the body side (right or left) affected by paresis and the applied rehabilitation methods. All the patients were applied the recommended kinesitherapeutic method (randomized), 35 therapy sessions, every day for a period of six weeks. Before initiation of therapy and after 6 weeks was measured the total area of the support and path length (COP (Center Of Pressure) measure foot pressure) using stabilometer platform – alpha. The results were statistically analyzed.

After treatment studied traits decreased in all groups. The greatest improvement was obtained in groups with NDT-Bobath therapy. NDT-Bobath method for improving the balance of the body is a more effective method of treatment in comparison with of the PNF method. In stroke patients, the effectiveness of NDT-Bobath method does not depend on hand paresis.

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1. Introduction

Vascular diseases of the brain, where stroke is the most dramatic complication is one of the major health social problems. Incidence, high mortality, recurrent nature and the significant disability of patients who have survived a stroke remain one of the major health problems in the world [1].

In 50% of these patients impaired balance and coordination, spatial orientation and distribution of body weight were observed [2–8].

The recovery of the patient's ability to walk or performing daily activities require proper training. Currently, the most commonly used are: NDT-Bobath method (Neurodevelopmental Treatment) and the method of PNF (Proprioceptive Neuromuscular Facilitation), which provide a comprehensive therapeutic approach. In the PNF method the main goal involves re-education of movement activities, which are assisted with previous experience and derived from the patterns of motor development as well as multi-sensory impulses. The procedure is based on the summation of various types of afferent stimuli (strong multisensory stimulation) [9].

Complex ''movement patterns'' improve motor function centers by stimulating receptors located deep in the muscles, ligaments and joint capsules. Much attention is paid to the patient's motor control, i.e. interaction between stability and mobility of the body, especially with regards to working conditions eccentric gravity.

The NDT-Bobath method it is a key factor in the correct sensation of movement, and the freeing of posture and movement patterns under the influence of incorrect posture reflex, through priming based on correct sitting and balance responses [10–13].

The method is systematically modified in accordance with the most updated medical knowledge and provides a comprehensive therapeutic approach. Currently, this method is a leading way of rehabilitation of patients after stroke in Western Europe [14]. The primary goal of the therapy with the NDT-Bobath method is to develop proper attitudes and adapting mechanism of normal patterns of postural and motor function in everyday life [15]. An appropriate support, obtained by moving the key points (head, neck and torso, shoulder girdle and upper limbs, hip girdle and lower limbs), initiates the activity of restoring reflex posture, balance and self-use by the patient and allows the accumulation of normal sensorimotor sensations [10–13,15].

In stroke patients, these methods are used to achieve the main objective of rehabilitation, which aims at the restoration of maximum patient independence in the shortest possible period of time.

The aim of the study is to evaluate the effect of the NDT-Bobath and PNF methods on the return balance to patients after a stroke.

2. Material and methods

The study included 72 patients (40 women, 32 men) aged from 20 to 69 years (mean age 53.7 years) after ischemic stroke with hemiparesis. 38 patients had paresis of the left side of the body and 34 had paresis of the right side. All patients treated in the Rehabilitation Clinic had suffered a stroke within 6 months before treatment. The study excluded patients:

- who had suffered more than one stroke or other neurological diseases with central nervous system damage;
- who could not remain standing;
- with incomplete or no logical-verbal contact;
- with pusher syndrome and (or) heminegolect syndrome;
- with a limited range of motion in the lower extremities due to osteoarthritis or amputation of lower limbs.

The patients were divided into 4 Groups. The criteria for this division were: the body side (right or left) affected by paresis and the applied rehabilitation methods.

- Group 1 comprised 17 patients (9 women and 8 men) aged from 21 to 56 years (mean age of 51.72 ± 5.95 years); had paresis of the right side of the body. The NDT-Bobath method was the chosen therapy for this Group.
- Group 2 comprised 21 patients (12 women and 9 men) aged from 20 to 68 years (mean age 53.64 ± 6.62 years); had paresis of the left side of the body. The NDT-Bobath method was the chosen therapy for this Group.
- Group 3 comprised 17 patients (10 women and 7 men) aged from 27 to 69 years (mean age of 52.32 ± 7.95 years); had paresis of the right side of the body. The PNF method was used in this Group.
- Group 4 comprised 17 patients (9 women and 8 men) aged from 31 to 69 years (mean age of 53.16 ± 6.95 years); had paresis of the left side of the body. The PNF method was used in this Group.

All the patients were applied the recommended kinesitherapeutic method (randomized), 35 therapy sessions, every day for a period of six weeks (except for Sundays). The classes were conducted individually by professional physiotherapists.

The movements used in physiotherapy based on the PNF method do not resemble those used by the muscles as part of their daily operation. Movements performed at work and in daily life are diagonal and spiral, and do not take place only in one plane.

Complex patterns of movement are the base of the method.

However, the key aim of the NDT-Bobath method is for its exercises to be compatible with the natural development of human mobility. The method is based on the assumption that deficits in movement resulting from damage to the central nervous system are impaired reflexes conditioning attitudes concerning movement coordination and control in relation to the environment.

Field support and total path length measure foot pressure (COP) were evaluated twice in all patients, before the start of therapy and after 6 weeks of therapy, with the use of an ALFA balance platform: a modern piece of equipment used for evaluation and balance training on a stable surface, which allows an objective evaluation of balance in static conditions: measurements of the area of support and the total path length traced by the center of foot pressure (COP) during the test [16].

The subject stood barefoot on the platform in the free position (lower extremities straight at the knees). The track width of the lower extremities and the feet opening angle was defined according to E-12 symbols; the disk platform is marked with symbols, letters and numbers along the horizontal and diagonal lines. During the test, the patients kept their eyes open and looked straight ahead. They did not see the results of their test on the screen. The duration of test was 30 s. A plate equipped with strain gauges recorded the movement of the COP on the platform. Displacement values were recorded by computer and displayed on the monitor screen: the surface area of the support (an envelope line was established from a combination of extreme stabilograph points forming an irregularly-shaped polygon) and the curve length (the length of the path which the COP followed during the test). Impaired balance control is manifested in increased path length.

The results were statistically analyzed. The Shapiro–Wilk test was used to assess the distribution of samples. For comparison, the following parameters were used:

- For an unrelated sample *t*-test, when at least one attempt was different from the normal distribution, the Mann–Whitney test was used.
- In the case of a related samples t test, when the distribution was different from normal, the Wilcoxon test was used (range of characters).

The authors used the RIR Tukeya Test for unequal sample sizes in order to compare data in the four groups.

The level of significance was $p < 0.05$.

3. Results

There were no significant differences between the 4 groups before treatment in terms of age, movement distance or the COP surface. For those with left-sided hemiparesis were higher values of the surface area of support. After 6 weeks of therapy, these values were measured again. Their changes are shown graphically in the following figures (Table 1, Fig. 1). The greatest shortening of the COP pathways was observed in Groups 1 and 2. In Group 1, the mean difference of the shortening of the path length of stabilogram was 126.16 mm, (which approximately makes up 48% of the initial value). In Groups 2, 3 and 4 the values were 128.16 (which is about 47% of the initial value), 87.79 mm (about 34%) and 59.89 mm (about 22%) respectively. After treatment, patients treated with PNF greater reduction of COP pathways were obtained in patients with right-hand paresis. The differences were statistically significant, Table 2.

After the treatment, a high statistical significance of shortening the path length of movement of the COP between the studied groups.

After the therapy with Bobath NDT, COP path length decreased in all patients with both paresis of the left and right sides. The value of this reduction was similar in all patients. There was no significant difference between patients with paresis of the left and right sides ($p = 0.996665$). The values of shortened COP path length were statistically significant all patients with both paresis of the left and right sides in whom the PNF method was administered.

Table 1 – Descriptive statistics of the study groups.

The variable		*n*	X	median	Minimum	Maximum	SD	Skewness
Group 1	COP-before	17	263.88	274.70	128.30	373.20	62.42	−0.28
	COP-after	17	137.59	145.40	61.20	187.60	35.18	−0.74
	Difference	**17**	**126.16**	**123.90**	**67.10**	**203.70**	**35.26**	**0.67**
	Field-before	17	169.88	165.00	72.40	293.30	45.60	0.82
	Field-after	17	65.49	68.90	11.70	123.10	27.73	−0.12
	Difference	**17**	**104.43**	**104.50**	**60.70**	**170.20**	**24.58**	**0.88**
Group 2	COP-before	21	271.12	264.50	193.60	416.00	44.28	1.78
	COP-after	21	143.10	135.30	91.50	251.50	40.05	1.91
	Difference	**21**	**128.16**	**123.80**	**72.70**	**173.40**	**24.55**	**−0.09**
	Field-before	21	218.53	201.90	173.50	320.70	42.20	1.47
	Field-after	21	118.72	106.20	79.20	219.70	37.46	1.89
	Difference	**21**	**99.80**	**100.90**	**70.20**	**129.10**	**16.10**	**0.25**
Group 3	COP-before	17	256.37	254.80	197.40	327.90	34.21	0.35
	COP-after	17	168.58	163.70	137.20	250.70	26.84	1.82
	Difference	**17**	**87.79**	**93.50**	**24.60**	**121.80**	**28.59**	**−1.07**
	Field-before	17	128.46	126.30	62.50	193.30	31.21	0.28
	Field-after	17	88.02	83.90	57.20	137.90	20.05	1.15
	Difference	**17**	**40.44**	**41.90**	**5.30**	**69.1**	**14.43**	**−0.36**
Group 4	COP-before	17	276.29	273.80	183.60	368.90	45.10	0.50
	COP-after	17	215.46	203.70	163.60	328.00	40.50	1.41
	Difference	**17**	**59.89**	**61.40**	**8.50**	**101.10**	**19.59**	**−0.58**
	Field-before	17	264.34	266.20	133.20	364.20	48.51	−0.76
	Field-after	17	205.94	203.10	77.10	293.10	54.11	−0.97
	Difference	**17**	**58.41**	**56.30**	**27.30**	**111.30**	**17.24**	**1.54**

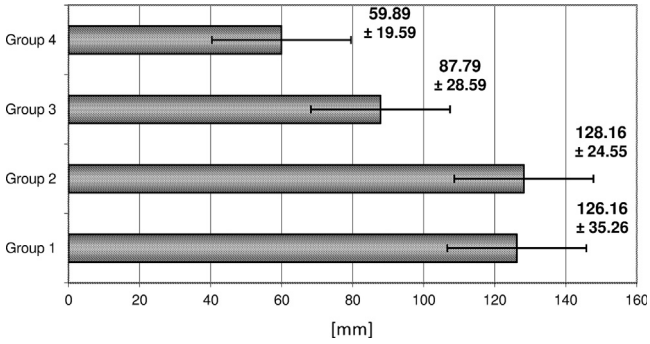

Fig. 1 – Differences movement path length of the COP.

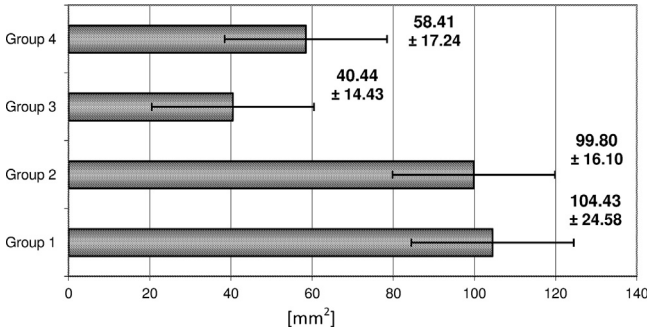

Fig. 2 – Difference in the surface area of support.

The COP shorten the analysis shows that the NDT-Bobath method has a greater effect on the reduction of said parameter in patients after stroke.

From the above analysis, it can be seen that the results were significantly worse in patients who received therapy based on PNF.

After treatment in the study groups were observed a similar trend to reduce the surface area of support. In each treatment group achieved the reduction in the surface area of support fields. The greatest shortening was observed in Groups 1 and 2. In patients who received Bobath-NDT therapy, an average reduction of the surface area of support of 104.43 mm^2 was seen in those with paresis of the right side (which approximately makes up 61% of the initial value), and 99.80 mm^2 in those with paresis of the left side (which approximately makes up 46% of the initial value). They are shown graphically in Fig. 2.

In the PNF group of patients, the surface of support decreased by 40.44 mm^2 in patients with paresis of the right side (which approximately makes up 31.5% of the initial value), and by 58.41 mm^2 in patients with paresis of the left side (which approximately makes up 22% of the initial value). The difference between the patients with paresis of the left and right side (Groups 1 and 2) was not statistically significant ($p = 0.883117$). After treatment by the PNF greater reduction of field support area was in patients with left-sided hemiparesis. The differences were statistically significant. From the above analysis, it can be seen that the results were significantly worse in patients who received therapy based on PNF. The results are presented in Table 3.

4. Discussion

Maintaining the standing posture requires constant monitoring, which depends on the precise neuromuscular coordination, which enables a human to keep balance in all conditions. The nervous system provides balance by reflex muscle tension or postural and anti-gravity muscles [12,17].

Table 2 – Statistical significance of differences in the path length of movement of the COP.

Paresis side	The difference in COP pathway length			
	(1)	(2)	(3)	(4)
	M = 126.16	M = 128.16	M = 87.79	M = 59.89
Group 1 (1)		0.996665	**0.000807**	**0.000151**
Group 2 (2)	0.996665		**0.000459**	**0.000151**
Group 3 (3)	**0.000807**	**0.000459**		**0.021295**
Group 4 (4)	**0.000151**	**0.000151**	**0.021295**	

Bolded differences are significant ($p < 0.05$).

Table 3 – Statistical significance of differences in the surface area of support.

Paresis side	Difference in the surface area of support			
	(1)	(2)	(3)	(4)
	M = 104.43	M = 99.80	M = 40.44	M = 58.41
Group 1 (1)		0.883117	**0.000151**	**0.000151**
Group 2 (2)	0.883117		**0.000151**	**0.000151**
Group 3 (3)	**0.000151**	**0.000151**		**0.028811**
Group 4 (4)	**0.000151**	**0.000151**	**0.028811**	

Bolded differences are significant ($p < 0.05$).

The results of studies conducted by Verheyden et al. confirm a strong a relationship between trunk control at an early stage and basic daily activities and predictive value of the assessment of postural control and the restoration of functions of everyday life in patients after stroke [18]. The assessment of the patient's ability to maintain a standing position on his/her own is often a key point in the evaluation of postural control after stroke [19]. The ability to control balance in sitting and standing positions is the basic condition to achieve independence in daily activities. Trunk control in patients after stroke has been recognized as closely correlated with a prognosis of a long-term functional improvement. Early assessment of trunk control and balance after stroke should be an important part of a clinical trial in the acute phase [20–23].

Posturagraphy is a set of research methods used to assess the quality of postural control. It allows an objective assessment of the movement of center of foot pressure (COP) while standing, which in static conditions, is the projection of the overall center of gravity on the plane the body is resting [16,24].

The center of body gravity (COG, center of gravity) does not stand still at one point, but performs small movements called sways, which add a slowly changing component to the movement of the COP position. Analysis of the movement of the COP in the standing position provides information about the current state of stability of the patient's body, which changes depending on the conditions for maintain balance. One of the most frequently evaluated parameters is the length of the path which the COP follows during the measurement [25]. Impaired control of standing balance is usually manifested in prolongation of the path length. More information concerning the balance control throughout the entire envelope is provided by stabilograph analysis (area support). If the most extreme points are connected with each other, an irregularly shaped polygon is formed. The surface area of the polygon is dependent on the degree of movement in all directions and acts as another parameter characterizing postural stability. It is an important indicator of balance control [21,26–28].

Significant differences were seen between patients treated by the two methods. The observed decrease of the studied variables indicates improvement in equilibrium of the body in a standing position-greater in the groups treated with the NDT-Bobath therapy. Postural reactions under the influence of NDT-Bobath therapy became more efficient and adapt to the situation, manifested by a shorter path length and reduced COP displacement field seen in the stabilograph [29].

Before starting treatment, stabilograph showed larger field in a standing position in patients with paresis of the left. The presented results confirm the value of the posturograph as an objective assessment of the body. The only aspects of the patient's condition which might prevent the test from being performed are the inability to stand unsupported on the platform or the inability to walk. The main advantages are that it is non-invasive and reproducible, allowing for a reliable assessment of parameters analyzed at intervals. An early diagnosis of balance disorder in combination with targeted therapy may reduce the adverse effects associated with it, and improve the condition of people after stroke.

5. Conclusions

1. The NDT-Bobath and PNF methods commonly used in the physiotherapy of patients after stroke have important therapeutic effects.
2. The NDT-Bobath method is an effective to reduce of the field support and total path length measure foot pressure (COP).
3. The side of paresis in patients after stroke does not affect the reduction on the field support and total path length measure foot pressure (COP) in patients after stroke, but greater improvement tested parameters are observed in patients with right-sided hemiparesis.
4. The evaluation of the field support and total path length measure foot pressure (COP) using posturagraphy is useful in the assessment of patients and monitoring treatment outcomes.

Conflict of interest

The authors declare no conflicts of interest

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Ethics

The Bioethics Committee of the Medical University of Lodz gave a consent for such a study to be conducted (no. RNN/665/11/KB). We received informed consent from each person to participate in your study.

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