

Normalized gait parameters in NDT-Bobath post-stroke gait rehabilitation

Research Article

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Abstract: The aim of the research was to evaluate the results of NDT-Bobath method in gait re-education of adult patients after ischemic stroke using normalized parameters of gait. The investigation group consisted of 60 patients, all sufferers of an ischemic stroke, and participated in a rehabilitation program: 10 sessions of NDT-Bobath therapy through 2 weeks (ten days of the therapy). Normalized parameters of gait were calculated based on anthropometric measures of patients and their gait parameters (gait velocity, cadence and stride length) measured in every patient on admission (before the therapy) and after the last session of the therapy to assess rehabilitation effects. Results among patients involved in the research were as follows:

- in normalized gait velocity: recovery in 42 cases (70%), relapse in 10 cases (16.67%), no measurable changes in 8 cases (13.33%),
- in normalized cadence: recovery in 39 cases (65%), relapse in 16 cases (26.67%), no measurable changes in 5 cases (8.33%),
- in normalized stride length: recovery in 50 cases (83.33%), relapse in 4 cases (6.67%), no measurable changes in 6 cases (10%).

Observed statistically significant and favourable changes in health status of patients, described by normalized gait parameters, confirm effectiveness of the NDT-Bobath method.

Keywords: *Rehabilitation • Ischaemic stroke • Normalized parameters of gait • NDT-Bobath • Gait re-education • Gait analysis*

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1. Introduction

The number of people who suffer from strokes is estimated to be 15 million including 5 million deaths each year. Stroke incidence rates in Poland are reported to vary between 125/100 000 and 175/100 000. The total number of stroke cases in Poland is estimated to 70 000 per year [1-6]. The effects of a stroke depend mainly on the injured area of the brain and severity of the lesion itself. It is estimated, that 60% of stroke survivors suffer from motor deficits and 50% of the cases result in patients who are left unable to fully care for themselves. [6,7]. Locomotion and performance of basic activities of living in post-stroke patients is compromised. Ischemic stroke constitutes 80-85 % of all stroke cases [1-5].

Particular attention in post-stroke rehabilitation is paid to searching for more effective ways restoring patients best possible functioning. The aim of this study was to assess the results of post-stroke rehabilitation based on NeuroDevelopmental Treatment - Bobath (NDT-Bobath) for adult's method in gait re-education

using normalized spatio-temporal gait parameters: normalized gait velocity, normalized cadence and normalized stride length. Normalized parameters are perceived as more reliable for compartmental studies, especially in the area of effectiveness of the particular method of rehabilitation.

NDT-Bobath for adult's method is one of the world-wide leading methods in post-stroke rehabilitation [8-14]. This method is not a set of exercises, but the whole concept containing clinical reasoning, movement analysis, analysis of level of disability, assessment of functional deficits and their causes. Efforts to unify this method lie in the attempts to integrate both sides of the body: affected and unaffected, avoiding compensatory strategies, integrating task-directed movements and postural control. Particular attention during rehabilitation is paid to the „direct” therapy: stimulation promoting use of affected side, use of sensory and proprioceptive inputs. The fundamental role plays plasticity of the brain, stimulated in restoration to normal state after central nervous system (CNS) damage and/or to modify its

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Table 1. Patients' overall profile.

	Number and percentage
Side of paresis:	
Left	30 (50 %)
Right	30 (50 %)
Sex:	
Females	30 (50 %)
Males	30 (50 %)
Age [years]:	
Min	42
Max	86
SD	10.3
Mean	65.7
Median	68
Age brackets [years]:	
38-47	2 (3.33 %)
48-57	13 (21.67 %)
58-67	13 (21.67 %)
68-77	27 (45 %)
78-87	5 (8.33 %)
Time after cerebrovascular accident (CVA):	
6 weeks – 6 months	20 (33.33 %)
> 6 months – 1 year	13 (21.67 %)
> 1 year – 2 years	14 (23.33 %)
> 2 years – 3 years	13 (21.67 %)

own structure and functions. NDT-Bobath therapists, to achieve therapeutic success, should be very good at analysis of normal physiological human movement, so it is necessary for them to have big knowledge in the area of anatomy, neurophysiology, neurology and biomechanics. Problem solving approach and analysis from cause to goals makes possible to plan the intervention. NDT-Bobath method, according to the Bobaths intent, is still developing and is revised each year.

One of the effects of CNS damage can be gait impairment, influencing mobility and activities of daily living (ADLs) of the patient. Despite wide use of NDT-Bobath method, there is lack of research in the area of post-stroke rehabilitation using NDT-Bobath method [15-19] including gait re-education [20-28].

2. Material and Methods

2.1. Patients

The study involved 60 patients post ischemic stroke. Study group were established on the basis of the criteria described. Inclusion criteria were as follows: age above 18 years, time after cerebrovascular accident (CVA) – from 6 weeks to 3 years and diagnosis: ischemic stroke. Inclusion of patients was each time confirmed by medical

records. The patients' profiles are presented in Table 1.

Size and anatomical involvement of infarct varied depend on patient and cannot be described general extent of involvement of motor areas and tracts (excerpt hemisphere).

The study was accepted by the appropriate Bioethical Committee. The subjects gave written informed consent before entering the study, in accordance with the recommendations of the Bioethical Committee, acting on the rules of Good Clinical Practice and the Helsinki Declaration.

2.2. Methods

Patients were treated according to the rules of the NDT-Bobath method by experienced therapists of NDT-Bobath for adult's method with international certificates:

- The International Bobath Instructors Training Association (IBITA) recognized Basic Course "Assessment and Treatment of Adults with Hemiplegia – The Bobath Concept",
- IBITA recognized Advanced Course "Assessment and Treatment of Adults with Neurological Conditions – The Bobath Concept",
- additionally (earlier) The European Bobath Tutors Association (EBTA) recognized course "NDT-Bobath Basic Course in the Assessment and Treatment of Children".

There was provided 10 sessions of the NDT-Bobath therapy through 2 weeks (10 days of the therapy - the therapy was performed from Monday to Friday each week). This two weeks time is a standardized period of outpatient rehabilitation in Poland. Each session lasted 30 minutes. My own method of gait analysis, described in [27], is based on gait recording using video camera, gait evaluation, measurement of temporo-spacial gait parameters (gait velocity, cadence, stride length) and their assessment and calculating normalized values using CGA Clinical Gait Analysis – free software developed by C. Kirtley MD [29]. Measurement and calculating of the normalized gait parameters (normalized gait velocity, normalized cadence and normalized stride length) were performed in every patient on admission (before the therapy) and after last session of the therapy to assess rehabilitation effects.

2.3. Statistical analysis

Statistical analysis of data was performed using the Statistica Software. The results are expressed as mean, median, maximal value, minimal value and SD. The results were statistically analyzed using the Wilcoxon's Test. A probability (p) value < 0.05 was considered as statistically significant.

Table 2. Results for whole group of patients.

	normalized gait velocity		normalized cadence		normalized stride length	
	number of patients	%	number of patients	%	number of patients	%
number of patients	60	100	60	100	60	100
recovery	42	70	39	65	50	83.33
relapse	10	16.67	16	26.67	4	6.67
no changes	8	13.33	5	8.33	6	10

Table 3. Statistical analysis of the results for whole group of patients.

	n	Mean	Median	Min	Max	SD
First examination						
Normalized gait velocity	54	0.171	0.170	0.040	0.320	0.074
Normalized cadence	54	0.387	0.410	0.150	0.510	0.095
Normalized stride length	54	1.694	1.760	0.380	2.610	0.528
Second examination						
Normalized gait velocity	58	0.231	0.245	0.020	0.530	0.131
Normalized cadence	58	0.420	0.445	0.060	0.760	0.158
Normalized stride length	58	1.998	2.055	0.710	3.210	0.663

In whole group of patients in normalized gait velocity: statistically significant ($p < 0.001$) recovery: mean increased from 0.171 (median: 0.170) in the first examination to 0.231 (median: 0.245) in the other. In whole group of patients in normalized cadence: statistically significant ($p=0.004$) recovery: mean increased from 0.378 (median: 0.410) in the first examination to 0.420 (median: 0.445) in the other. In whole group of patients in normalized stride length: statistically significant ($p < 0.001$) recovery: mean increased from 1.694 (median: 1.760) in the first examination to 1.998 (median: 2.055) in the other.

Table 4a. Results in the area of normalized gait velocity depend on side of paresis.

	right		left	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	22	73.33	20	66.67
relapse	3	10	7	23.33
no changes	5	16.67	3	10

In the group of patients with right side of paresis in normalized gait velocity: statistically significant ($p < 0.001$) recovery: mean increased from 0.165 (median: 0.165) in the first examination to 0.234 (median: 0.210) in the other. In the group of patients with left side of paresis in gait velocity: statistically significant ($p = 0.003$) recovery: mean increased from 0.177 (median: 0.180) in the first examination to 0.227 (median: 0.250) in the other.

Table 4b. Results in the area of normalized gait velocity depend on sex.

	female		male	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	16	53,33	26	86,67
relapse	8	26,67	2	6,67
no changes	6	20	2	6,67

In the group of females in normalized gait velocity: statistically significant ($p = 0.016$) recovery: mean increased from 0.153 (median: 0.160) in the first examination to 0.199 m/s (median: 0.195) in the other. In the group of males in gait velocity: statistically significant ($p < 0.001$) recovery: mean increased from 0.190 (median: 0.180) in the first examination to 0.261 (median: 0.255) in the other.

3. Results

The results are presented in Tables 2-6. My research has focused on determination of changes observed as results of the therapy conducted according to the NDT-Bobath method rules in group of patients after ischemic stroke in the area of gait parameters: normalized gait velocity, normalized cadence and normalized stride length. These elements are often impaired as a result of the stroke. There were statistically relevant changes reflecting recovery in normalized gait parameters as the result of the therapy using NDT-Bobath method.

3.1. Gait velocity

Results in gait velocity among 60 patients (100%) involved in the study were as follows: recovery in 39 cases (65%), relapse in 9 cases (15%), no measurable changes in 12 cases (20%).

3.2. Cadence

Results in cadence among 60 patients (100%) involved in the study were as follows: recovery in 39 cases (65%), relapse in 16 cases (26.67%), no measurable changes in 5 cases (8.33%),

Table 4c. Results in the area of normalized gait velocity depend on age.

	38-47 years		48-57 years		58-67 years		68-77 years		78-87 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	2	100	13	100	13	100	27	100	5	100
recovery	2	100	7	53.85	8	61.54	23	85.19	2	40
relapse	0	0	3	23.08	4	30.77	2	7.41	1	20
no changes	0	0	3	23.08	1	7.69	2	7.41	2	40

For purposes of statistical analysis whole group was divided into two groups using median (68 years). In the group of patients younger than 68 years in normalized gait velocity: statistically significant ($p = 0.001$) recovery: mean increased from 0.176 (median: 0.170) in the first examination to 0.240 (median: 0.230) in the other. In the group of patients older than 68 years in gait velocity: statistically significant ($p < 0.001$) recovery: mean increased from 0.164 (median: 0.170) in the first examination to 0.219 (median: 0.245) in the other.

Table 4d. Results in the area of normalized gait velocity depend on time after CVA.

	6 weeks – 6 months		> 6 months – 1 year		> 1 year – 2 years		> 2 years – 3 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	17	100	12	100	17	100	14	100
recovery	12	70.59	8	66.67	13	76.47	9	64.29
relapse	3	17.65	1	8.33	2	11.77	3	21.43
no changes	2	11.77	3	25	2	11.77	2	14.29

In the group of patients since 6 weeks to 6 months after CVA in normalized gait velocity: statistically significant ($p = 0.023$) recovery: mean increased from 0.179 (median: 0.180) in the first examination to 0.207 (median: 0.205) in the other. In the group of patients since 6 months to 1 year after CVA in gait velocity: statistically significant ($p = 0.025$) recovery: mean increased from 0.148 (median: 0.170) in the first examination to 0.222 (median: 0.220) in the other. In the group of patients since 1 year to 2 years after CVA in gait velocity: statistically significant ($p = 0.002$) recovery: mean increased from 0.186 (median: 0.200) in the first examination to 0.268 (median: 0.250) in the other.

Table 5a. Results in the area of normalized cadence depend on side of paresis

	right		left	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	22	73.33	17	56.67
relapse	6	20	10	33.33
no changes	2	6.67	3	10

In group of patients with right side of paresis in normalized cadence: statistically significant ($p = 0.003$) recovery: mean increased from 0.379 (median: 0.410) in the first examination to 0.427 (median: 0.450) in the other.

Table 5b. Results in the area of normalized cadence depend on sex.

	female		male	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	16	53.33	23	76.67
relapse	10	33.33	6	20
no changes	4	13.33	1	3.33

In group of males in cadence: statistically significant ($p = 0.003$) recovery: mean increased from 0.395 (median: 0.41) in the first examination to 0.447 (median: 0.475) in the other.

3.3. Stride length

Results in stride length among 60 patients (100%) involved in the study were as follows: recovery in 50 cases (83.33%), relapse in 4 cases (6.67%), no measurable changes in 6 cases (10%).

4. Discussion

As a result of therapy using NDT-Bobath method were observed statistically significant changes in patients' health status. These changes in the area of normalized gait parameters were favorable. Based on them, the better prognosis in the area of normalized gait velocity

are for patients as follows: men, 1-2 years after CVA, 38-47 years old, left side of paresis. Better prognosis in the area of normalized cadence is for patients as follows: men, 1-2 years after CVA, 38-47 years old, right side of paresis. Better prognosis in the area of normalized stride length are for patients as follows: men, 1-2 years after CVA, 38-47 years old, right side of paresis. Differences between patients with left side of paresis and right side of paresis were small.

Relapse in outcomes was result of the specificity of the NDT-Bobath method: it pays particular attention firstly to the gait quality and next stages of the therapy should improve these gait parameters because of better gait quality, changing "virtual" relapse into recovery. This

Table 5c. Results in the area of normalized cadence depend on age.

	38-47 years		48-57 years		58-67 years		68-77 years		78-87 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	2	100	13	100	13	100	27	100	5	100
recovery	2	100	7	53.85	8	61.54	20	74.07	2	40
relapse	0	0	6	46.15	4	30.77	5	18.52	1	20
no changes	0	0	0	0	1	7.69	2	7.41	2	40

For purposes of statistical analysis whole group was divided into two groups using median (68 years). In the group of patients older than 68 years in normalized cadence: statistically significant ($p = 0,006$) recovery: mean increased from 0,368 (median: 0,410) in the first examination to 0,398 (median: 0,425) in the other.

Table 5d. Results in the area of normalized cadence depend on time after CVA.

	6 weeks – 6 months		> 6 months – 1 year		> 1 year – 2 years		> 2 years – 3 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	17	100	12	100	17	100	14	100
recovery	10	58.82	8	66.67	13	76.47	8	57.14
relapse	4	23.53	3	25	4	23.53	5	35.72
no changes	3	17.65	1	8.33	0	0	1	7.14

In group of patients since 1 year to 2 years after CVA in normalized cadence: statistically significant ($p = 0,044$) recovery: mean increased from 0.421 (median: 0.41) in the first examination to 0.479 (median: 0.51) in the other.

Table 6a. Results in the area of normalized stride length depends on side of paresis.

	right		left	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	25	83.33	24	80
relapse	1	3.33	4	13.33
no changes	4	13.33	2	6.67

In the group of patients with right side of paresis in normalized stride length: statistically significant ($p < 0,001$) recovery: mean increased from 1.651 (median: 1.605) in the first examination to 1.987 (median: 1.9) in the other. In the group of patients with left side of paresis in gait velocity: statistically significant ($p < 0,001$) recovery: mean increased from 1.741 (median: 1.79) in the first examination to 2.009 (median: 2.07) in the other.

Table 6b. Results in the area of normalized stride length depends on sex.

	female		male	
	number of patients	%	number of patients	%
number of patients	30	100	30	100
recovery	23	76.67	27	90
relapse	2	6.67	2	6.67
no changes	5	16.67	1	3.33

In the group of females in normalized stride length: statistically significant ($p < 0,001$) recovery: mean increased from 1.525 (median: 1.55) in the first examination to 1.794 (median: 1.835) in the other. In the group of males in gait velocity: statistically significant ($p < 0,001$) recovery: mean increased from 1.864 (median: 1.850) in the first examination to 2.188 (median: 2.285) in the other.

can be result of the core of gait re-education according to NDT-Bobath rules: it provides full gait re-education paying particular attention to gait quality, especially during the first stages of the therapy. Next stages pay particular attention to achievements in spatio-temporal gait parameters.

Limitation of this research is lack of control group. Nevertheless my results can be important step toward better understanding of gait rehabilitation using NDT-Bobath method. Based on this study I am going to continue my research, I hope using control group, providing full evidence.

There is lack of studies using NDT-Bobath for adults method to compare outcomes of my study, both normalized and non-normalized. Case study of Lennon

[20] and a systematic literature review of fifteen clinical trials performed by Paci [15] are widely discussed. Paci perceived need for further investigations to develop outcome measures concerning goals of the Bobath approach (motor performance, etc.). One of important criteria in the study should be deep knowledge of therapists about NDT-Bobath for adult's method, confirmed with international certificates and several years of experience in it [15,17].

Further research into the role of NDT-Bobath in post-stroke gait re-education is needed to establish the proper ways of the therapy. Independent sources of knowledge are necessary to estimate effectiveness of the NDT-Bobath method for adults in gait re-education in post-stroke patients.

Table 6c. Results in the area of normalized cadence depend on age.

	38-47 years		48-57 years		58-67 years		68-77 years		78-87 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	2	100	13	100	13	100	27	100	5	100
recovery	2	100	11	84.62	10	76.92	25	92.59	2	40
relapse	0	0	0	0	2	15.39	1	3.70	1	20
no changes	0	0	2	15.39	1	7.69	1	3.70	2	40

Whole group, for purposes of statistical analysis, was divided into two groups according to median (68 years). In the group of patients younger than 68 years in normalized stride length: statistically significant ($p < 0.001$) recovery: mean increased from 1.7 (median: 1.79) in the first examination to 2.031 (median: 2.110) in the other. In the group of patients older than 68 years in normalized stride length: statistically significant ($p = 0.001$) recovery: mean increased from 1.687 (median: 1.630) in the first examination to 1.957 (median: 1.865) in the other.

Table 6d. Results in the area of normalized cadence depend on time after CVA.

	6 weeks – 6 months		> 6 months – 1 year		> 1 year – 2 years		> 2 years – 3 years	
	number of patients	%	number of patients	%	number of patients	%	number of patients	%
number of patients	17	100	12	100	17	100	14	100
recovery	14	82.35	9	75	16	94.12	11	78.57
relapse	2	11.77	0	0	1	5.88	2	14.29
no changes	1	5.88	3	25	0	0	1	7.14

In the group of patients since 6 weeks to 6 months after CVA in normalized stride length: statistically significant ($p = 0.003$) recovery: mean increased from 1.767 (median: 1.790) in the first examination to 1.903 (median: 1.960) in the other. In the group of patients since 6 months to 1 year after CVA in stride length: statistically significant ($p = 0.012$) recovery: mean increased from 1.612 m (median: 1.55) in the first examination to 1.942 (median: 1.82) in the other. In the group of patients since 1 year to 2 years after CVA in stride length: statistically significant ($p < 0.001$) recovery: mean increased from 1.758 (median: 1.81) in the first examination to 2.164 (median: 2.22) in the other. In the group of patients since 2 year to 3 years after CVA in stride length: statistically significant ($p = 0.041$) recovery: mean increased from 1.595 (median: 1.595) in the first examination to 1.595 (median: 1.595) in the other.

In conclusion my results discussed here provide us with valuable information about effects of NDT-Bobath therapy in post-stroke gait re-education. There have been observed statistically significant and favorable

changes in health status of patients, described by normalized gait parameters. My results confirm, that NDT-Bobath method for adults is effective way of gait re-education in adult patients after ischemic stroke.

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