Location of the ischemic focus in rehabilitated stroke patients with impairment of executive functions

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Abstract

Background. Executive dysfunctions are part of the clinical symptoms of a stroke and can inhibit the process of rehabilitation. Patients with impaired executive functions may manifest aggression, impulsiveness, impaired thinking and planning.

Objectives. The aim of this study was to assess the effect of the ischemic focus location on the effectiveness of physiotherapy in improving the executive functions in patients after stroke.

Material and methods. Ninety patients after unilateral ischemic cerebral stroke were studied. We studied 45 patients treated at the Department of Rehabilitation and Physical Medicine of the WAM University Hospital of Lodz for 5 weeks. The rehabilitation program included: kinesitherapy, physiotherapy, speech therapy, psychological consultations and psychotherapy. The control group consisted of patients who were waiting for admission to the Department of Rehabilitation. The patients in both groups were divided into three subgroups with different locations of stroke: front, back and subcortical. Executive functions were measured by the Wisconsin Card Sorting Test (WCST), the trail making test (TMT - A, TMT - B), the verbal fluency test (VFT).

Results. Patients rehabilitated in the hospital with the front and subcortical lesion location reported improvement in executive functions in terms of a greater number of the analyzed indicators of the Wisconsin Card Sorting Test (WCST) than those with the back lesion location. Patients rehabilitated at home with the subcortical lesion location did not experience a significant improvement in executive functions in any of the analyzed indicators of the Wisconsin Card Sorting Test (WCST). Most of the indicators, with the exception of the total errors of Wisconsin Card Sorting Test (WCST) and TMT B, have not been modified by the location of stroke.

Conclusions. Executive dysfunction occurs not only in patients with an anterior location of the stroke, but also in the posterior and subcortical locations. Patients with a subcortical location of the stroke require more treatment to mitigate the dysfunction.

Key words: rehabilitation, executive functions, stroke

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Stroke is the main cause of severe and long-term disabilities in the adult population. Each year 50–70% out of about 40,000 patients after stroke require constant treatment_and rehabilitation.¹ As a result of a stroke, there are severe motor dysfunctions, such as paralysis, paresis, gait and balance impairment and also cognitive deficits and emotional disorders. Over the five years after the first stroke, 30–40% of patients suffer from recurrent stroke.² In this situation, it is important to search for and find out about the factors that may influence the process of treatment and rehabilitation after stroke.

Executive functions are involved in almost every human activity with the exception of automated and learned activities. The individual components of activities such as starting, stopping and shifting are under the executive control. The executive functions integrate and organize various complex cognitive processes by which human behavior is planned, purposeful, conscious and selective.^{3,4}

The brain substrate of executive functions both in terms of localization and etiology are a matter of argument. Initially, executive dysfunction was associated mainly with damage to the frontal lobes of the brain and has been reported as frontal dysexecutive syndrome.⁵ Intensive development of medical sciences: neurology, psychiatry, neurobiology, psychophysiology has shown a wider spectrum of such disorders.³ Fuster argued that the limitation of the concept of executive functions to the frontal lobes only simplifies the meta-cognitive-behavioral process which are the essence of the central executive system. Executive dysfunctions occur not only with lesions in the frontal cortex, but also in other subcortical structures such as: basal nuclei, hippocampus, striatum, thalamus, hypothalamus and cerebellum and cortex of other lobes of the brain.6 Usually the infarction of frontal lobes, the striatum and the thalamus are mentioned among the causes of ischemic disorders of executive functions.3

The aim of this study was to investigate the effect of ischemic focus location in people after stroke on the effectiveness of the rehabilitation process for the return of executive functions.

Material and methods

Ninety patients after ischemic stroke were examined. The study group (45 individuals) were patients rehabilitated in the Department of Rehabilitation and Physical Medicine of the WAM University Hospital of Lodz. A rehabilitation program which consisted of physiotherapy, kinesitherapy, speech therapy, psychological consultation and psychotherapy was implemented. Physiotherapy was carried out with the use of modern neurophysiological methods such as Proprioceptive Neuromuscular Facilitation (PNF) and Bobath concepts and methods based on biofeedback. The patients were examined twice – first

before the rehabilitation and then at the end of the 5-week rehabilitation program.

The control group consisted of patients waiting for admission to the Department of Rehabilitation, rehabilitated at home. The study included patients after ischemic stroke, from a month to a year after the brain incident. All the patients were right-handed. The studies did not include patients with damage to both hemispheres and diffuse brain damage, previous neurological disorders with total aphasia, and suspected of having dementia or psychotic symptoms.

The patients in both groups were divided into 3 subgroups with regard to the different lesion locations of stroke: front, back and subcortical. All the patients were instructed on the aim of the studies and agreed to participate in them. They were informed about the voluntary participation and the possibility of withdrawal without giving a specific cause. The testing was approved by the Committee on Bioethics (No. RNN/242/10/KB of 18 May 2010).

Executive functions were assessed using the Wisconsin Card Sorting Test (WCST), the trail making test (TMT A TMT - B) and the verbal fluency test (VFT).

The Wisconsin Card Sorting Test (WCST) consists of 2 identical packs of cards (each pack contains 64 cards) and 4 reference cards. Using the feedback provided by the examiner, the subject is trying to lay the card according to the shape, color and number. This test requires retaining information about the currently accepted criterion, potentially possible choices and the implementation plan for solving the problem in the direct memory.

Higher test indicators for total errors, perseverative responses, perseverative errors, percent of perseverative errors, nonperseverative errors, responses trials to complete the first category, failure to maintain set, and lower scores in percentage of conceptual-level responses and categories achieved are indicative of more impaired executive functions.⁷

The trail making test (TMT) consists of 2 parts: TMT A and TMT B. TMT examines psychomotor speed (part A) and visual-spatial working memory as well as the ability to switch to a new criterion after learning a response rule (part B). The result of the test is the time in seconds obtained in parts A and B and the ratio of the time A/B. The parameter B/A greater than 3 indicates a serious disorder of executive functions.³

The verbal fluency test (VFT) consists of a letters test and a category test. In the category test, the patients are to provide as many words from each category as they can, and in the letter test, as many words starting with the given letter of the alphabet as they can in 1 min. On average, the persons without brain damage mention 13–14 words beginning with the given letter in 1 min and give 16–17 names from a specific category. The test assesses 3 basic components of executive functions: starting (initiating the task – finding the words starting with the given letter in memory resources), stopping (restraining

previous reactions – the task of administering the words of a given category), and maintaining (sustaining mental focus on the task), and self-monitoring (checking and monitoring commenced operations).³

In order to evaluate the effects of rehabilitation, the t-test for dependent data was used to indicate the significance of differences between mean values of the results in different rates in the 2 groups of people after stroke: treated in the hospital and treated at home in different lesion locations (front, back and subcortical) obtained before and after rehabilitation. Descriptive data are presented as means and standard deviations. The level of significance p < 0.01.

In order to investigate the union between localization of ischemic focus (front, back and subcortical) with the effects of rehabilitation depending on the kind of rehabilitation (in the hospital, at home), the ANOVA test the Kruskal-Wallis test and the Mann-Whitney test were used to compare differences in location of ischemic focus in groups. Descriptive data are presented as means, standard deviations and medians. The level of significance p < 0.05.

The STATISTICA v. 12 was used for data analysis.

Results

The following indicators of the Wisconsin Card Sorting Test (WCST) were used to evaluate changes in the key components of the executive functions of planning activities, their implementation and the control of cognitive rehabilitation following stroke in patients with varying location of stroke: total errors, perseverative responses, perseverative errors, percent of perseverative errors, nonperseverative errors, percentage of conceptual-level responses, categories achieved responses, trials to complete the first category, failure to maintain focus and the results of the trail making test (TMT) part B, and of the category test of verbal fluency test (VFT) and the letter test of verbal fluency test (VFT).

Patients rehabilitated in the hospital with the front and subcortical lesion location reported improvement in executive function in terms of a greater number of the analyzed indicators of the Wisconsin Card Sorting Test (WCST) than those with the back lesion location. Patients rehabilitated at home with the subcortical lesion location did not obtain a significant improvement in executive functions in any of the analyzed indicators of the Wisconsin Card Sorting Test (WCST) (Table 1).

Patients rehabilitated in the hospital, both the front, back and subcortical lesion location and rehabilitated at home with the subcortical lesion location showed a significant improvement in the control of the executive functions measured by the Trail Making Test (TMT B) (p < 0.01).

In the case of index B/A the only significant improvement was reported in the group with the front lesion location rehabilitated in the hospital (p < 0.01) (Table 2).

The results of category test and letter test of verbal fluency test (VFT) were used to assess the verbal aspect of executive functions in both groups rehabilitated in the hospital and at home with different lesion locations.

Patients after a stroke with front and subcortical lesion locations rehabilitated in the hospital showed an improvement executive functions in the verbal aspect of a larger number of indicators analyzed in comparison to those with the back lesion location.

The location of ischemic focus had no statistically significant effect on the results of the indicators of Wisconsin Card Sorting Test (WCST) in the hospital group (p > 0.05). In the group of patients rehabilitated at home statistically significant importance was the indicator of Wisconsin Card Sorting Test (WCST) – total errors (p < 0.05).

The indicators of improvement (difference between the results obtained by patient after rehabilitation and the results obtained before the rehabilitation) in total errors in a group of subcortical location of ischemic focus was significantly lower than in the group with the location of the front and back (p < 0.05).

The other indicators of Wisconsin Card Sorting Test (WCST) have not been modified by the location of stroke (p > 0.05).

In patient rehabilitated at home indicators of improvement in the ratio of trail making test B (TMT B) was significantly lower in patients with back lesion location of stroke than in the group with the location of the front and subcortical (p < 0.05).

Indicators of improvement in test categories and test letter of verbal fluency test (VFT) was not modified by the location of stroke.

Discussion

The results of this study confirmed the possibility of occurrence of executive disorders not only in the case of the front location of stroke, but also in the case of back and subcortical locations. Failure within the frontal cortex can lead to dysfunction of planning, controlling operations, disordered control of impulses, affective behavior disorders, as well as sleep disorders resulting in the interference of selectivity and accuracy of mental processes.^{8–11}

Patients with lesion location in the frontal lobes sometimes demonstrate impulsivity, aggression, disinhibition, low self-criticism and a tendency to break social norms and rules. The patients also have difficulty with abstract thinking. The connection between the frontal lobes and the striatum create a complex system that is responsible for planning the response and selecting the goals. The striatum is considered part of the anatomical circuit responsible for the processes of controlling the course of cognitive operations. Stroke patients with subcortical location of stroke within the striatum may have problems with stopping commenced operations and abnormal

Table 1. Results of Wisconsin Card Sorting Test (WCST) obtained before and after rehabilitation in patients rehabilitated in the hospital and at home with various localizations of ischemic focus

		Localization		Time of dat				
Variable	Group	of ischemic	bef	ore	af	ter	t	p < 0.01
		focus	M	SD	М	SD		
		front	66.11	11.93	42.68	18.12	5.671	0.000
	1	back	61.31	10.40	45.00	12.56	4.067	0.002
Total errors		subcortical	63.31	13.40	36.46	17.29	5.026	0.000
iotal ellois		front	50.44	6.82	39.63	13.12	3.181	0.006
	2	back	55.25	9.97	42.83	11.40	3.433	0.006
		subcortical	58.00	13.16	57.24	13.08	0.313	0.758
		front	54.68	23.66	31.53	12.48	3.999	0.001
	1	back	45.92	20.48	34.08	16.12	1.858	0.088
Perseverative		subcortical	45.85	25.62	24.62	11.96	2.419	0.032
responses	2	front	49.13	15.44	34.81	11.20	3.803	0.002
		back	50.42	17.07	39.58	12.28	2.083	0.061
		subcortical	46.88	16.55	43.94	13.01	0.812	0.428
		front	41.58	17.32	23.11	8.79	4.840	0.000
	1	back	32.62	12.04	23.46	10.56	2.238	0.045
Perseverative		subcortical	37.08	14.97	17.62	8.17	3.490	0.004
errors	2	front	28.94	11.77	20.38	7.88	2.692	0.017
		back	33.08	12.00	25.75	8.98	1.837	0.093
		subcortical	28.12	16.40	26.94	11.51	0.452	0.657
		front	37.42	19.68	19.53	5.55	3.981	0.001
	1	back	25.54	9.35	19.31	7.65	2.056	0.062
Percent of perseverative		subcortical	29.08	11.63	17.38	5.35	3.100	0.009
errors		front	22.50	9.24	17.00	5.96	2.370	0.032
	2	back	25.83	9.61	21.67	6.65	1.457	0.173
		subcortical	22.12	12.76	21.29	8.81	0.410	0.687
Non		front	24.47	13.53	19.58	12.54	1.109	0.282
Non- perseverative errors	1	back	28.69	10.40	21.46	10.44	2.265	0.043
		subcortical	26.23	8.49	19.00	13.20	2.214	0.047

 $¹⁻group\ rehabilitated\ in\ the\ hospital;\ 2-group\ rehabilitated\ at\ home;\ M-mean;\ SD-standard\ deviation.$

Table 1. Results of Wisconsin Card Sorting Test (WCST) obtained before and after rehabilitation in patients rehabilitated in the hospital and at home with various localizations of ischemic focus (cont.)

		Localization		Time of da				
Variable	Group	of ischemic	bef	ore	af	ter	t	p < 0.01
		focus	M	SD	M	SD		
Non-		front	22.75	10.17	20.06	12.05	0.924	0.37
perseverative errors	2	back	21.58	11.36	17.08	9.77	1.855	0.091
		subcortical	29.71	12.65	29.47	11.47	0.118	0.907
		front	30.42	11.21	54.47	16.11	5.911	0.000
	1	back	37.92	9.22	51.46	16.37	2.925	0.013
Percentage of conceptual-		subcortical	33.31	13.19	58.77	16.73	5.456	0.000
level responses		front	44.44	6.67	55.44	13.68	3.650	0.002
	2	back	42.75	9.45	52.42	11.37	2.506	0.029
		subcortical	36.06	12.01	39.47	11.78	1.452	0.166
		front	1.11	0.83	4.28	1.64	7.504	0.000
	1	back	1.92	1.61	4.15	1.46	6.512	0.000
Categories achieved		subcortical	1.69	1.38	4.31	1.89	5.226	0.000
responses		front	1.94	1.61	3.38	2.60	3.032	0.008
	2	back	2.08	1.73	4.00	2.30	3.286	0.007
		subcortical	0.76	0.97	1.41	1.54	2.098	0.052
	1	front	34.11	28.73	19.61	14.63	2.060	0.055
		back	25.92	27.46	21.77	19.16	0.488	0.634
Trials to complete the		subcortical	25.08	23.09	12.77	10.86	1.988	0.07
first category		front	29.56	23.66	16.13	15.37	2.053	0.058
	2	back	32.67	20.57	18.83	17.39	1.402	0.188
		subcortical	12.53	21.04	18.94	22.44	0.797	0.437
		front	2.06	1.76	1.44	1.25	1.377	0.186
	1	back	2.08	1.93	1.46	1.13	1.075	0.303
Failure to		subcortical	1.77	1.17	1.69	1.49	0.154	0.88
maintain focus		front	3.31	1.40	2.50	2.34	1.094	0.291
	2	back	2.50	2.15	1.58	1.83	1.836	0.094
		subcortical	2.94	2.05	2.29	2.42	1.335	0.201

 $¹⁻group\ rehabilitated\ in\ the\ hospital; 2-group\ rehabilitated\ at\ home; M-mean; SD-standard\ deviation.$

Table 2. Results trail making test (TMT B) and TMT B/A obtained before and after rehabilitation in patients rehabilitated in the hospital and at home with various localizations of ischemic focus

Variable		Localization		Time of dat				
	Group	of ischemic	bef	ore	aft	ter	t	p < 0.01
		focus	M	SD	М	SD		
		front	303.7	172.1	177.7	70.36	4.186	0.001
	1	back	305.9	247.7	215.3	171.2	3.391	0.005
TMT B		subcortical	277.5	110.4	175.6	81.71	6.377	0.000
TIVIT D	2	front	221.6	113.8	182.6	80.41	2.629	0.019
		back	130.1	78.91	116.9	61.40	1.498	0.162
		subcortical	287.8	109.9	239.3	90.77	3.523	0.003
		front	2.75	0.86	2.19	0.62	3.005	0.008
	1	back	3.02	1.98	2.44	1.02	1.752	0.105
B/A		subcortical	2.96	1.46	2.69	1.17	1.379	0.193
D/A	2	front	2.40	0.70	2.50	0.82	0.501	0.623
		back	2.00	0.35	1.97	0.32	0.208	0.839
		subcortical	3.24	1.05	3.00	1.36	0.712	0.487

 $¹⁻group\ rehabilitated\ in\ the\ hospital; 2-group\ rehabilitated\ at\ home;\ M-mean;\ SD-standard\ deviation.$

Table 3. Results of verbal fluency test (VfT) obtained before and after rehabilitation in patients rehabilitated in the hospital and at home with various localizations of ischemic focus

		Localization		Time of da				
Variable	Group	of ischemic	bef	ore	aft	ter	t	p < 0.01
		focus	M	SD	M	SD		
		front	6.11	3.09	9.47	2.89	5.113	0.000
	1	back	7.46	4.43	10.15	4.60	4.815	0.000
f No. of words		subcortical	7.85	3.02	9.69	3.95	2.984	0.011
T No. of words	2	front	7.44	4.21	8.69	3.24	2.402	0.03
		back	11.33	3.50	12.08	2.47	0.806	0.437
		subcortical	6.71	4.48	8.59	4.66	0.812	0.001
		front	5.53	3.47	8.63	3.02	4.572	0.000
	1	back	6.77	4.19	10.23	5.12	3.304	0.006
A No. of words		subcortical	7.15	2.58	9.77	3.61	2.339	0.037
A No. of Words	2	front	6.56	3.72	8.63	3.26	3.741	0.002
		back	10.42	2.81	12.58	3.23	2.545	0.027
		subcortical	5.88	4.78	6.88	3.57	1.011	0.327

 $¹⁻group\ rehabilitated\ in\ the\ hospital;\ 2-group\ rehabilitated\ at\ home;\ M-mean;\ SD-standard\ deviation.$

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Table 3. Results of verbal fluency test (VFT) obtained before and after rehabilitation in patients rehabilitated in the hospital and at home with various localizations of ischemic focus (cont.)

		Localization		Time of dat				
Variable	Group	of ischemic focus		ore		ter	t	p < 0.01
		locus	M	SD	M	SD		
		front	6.63	3.73	8.68	3.40	3.572	0.002
	1	back	7.62	4.79	10.00	5.49	1.865	0.087
S No. of words		subcortical	6.77	2.80	9.62	3.38	4.321	0.001
3 No. Of Words		front	6.25	3.32	7.81	3.23	2.581	0.021
	2	back	9.67	3.28	12.92	3.32	2.950	0.013
		subcortical	5.76	4.91	6.47	3.62	0.820	0.424
	1	front	9.11	5.05	10.47	4.54	1.587	0.130
		back	8.77	5.29	11.08	4.65	3.379	0.005
ZW No. of		subcortical	10.38	2.75	13.62	2.93	4.395	0.001
words	2	front	9.25	4.80	10.38	4.70	1.140	0.272
		back	13.00	3.13	13.58	5.79	0.466	0.65
		subcortical	9.18	7.15	10.53	5.89	1.743	0.101
		front	7.79	3.63	10.21	2.92	4.076	0.001
	1	back	8.54	4.03	10.54	4.86	1.775	0.101
ONe of words		subcortical	8.69	3.59	12.15	2.44	4.629	0.001
O No. of words	2	front	8.50	4.20	9.06	2.91	0.753	0.463
		back	11.08	3.53	12.67	4.27	2.130	0.057
		subcortical	7.82	5.66	8.94	4.90	1.924	0.072

^{1 –} group rehabilitated in the hospital; 2 – group rehabilitated at home; M – mean; SD – standard deviation.

attention switching, which means switching between individual aspects of executive actions. 12 However, the location of stroke in the structures of the limbic system often disturbs the execution control of emotions, motivation and drive to action. 13

With the view to the foregoing, problems of executive dysfunctions due to their different nature should be taken into account when planning the treatment and rehabilitation as it can greatly modify the process. Jodzio et al. noted the most severe executive dysfunctions in patients with the lesion location in the frontal lobes and certain subcortical structures such as the striatum, the thalamus, the internal capsule and the stem. ¹⁴ The studies by Goldberg, Summerfield et al. also show a large dis-

proportion in executive dysfunction symptoms between patients with damage to the front of the brain, patients with damage to the back of the brain, always to the disadvantage of the former.¹⁴

To investigate the influence of stroke location on the effectiveness of the rehabilitation process is a source of new relevant information. Patients rehabilitated in the hospital with front and subcortical lesion location achieved improvement of executive functions of a larger number of indicators of the Wisconsin Card Sorting Test (WCST) than those with the back location. Patients rehabilitated in the hospital with front and subcortical lesion location coped better with the choice of an appropriate strategy for solving the problem (correct sorting criterion) as they could

Table 4. The rating indicators in Wisconsin card sorting test (WCST) in patients rehabilitated in the hospital and at home depending on the location of ischemic focus

	p < 0.05		0.4116	0.021 0.889 0.020 0.019	0.438	0.085	0.254	0.138	0.159	0.340	0.735	0.497	0.132	0.113	0.316	0.156	0.474	0.073	0.691	0.892
	Value of the test		H=1.78	$H = 7.75$ $Z_{12} = 0.14$ $Z_{13} = 2.32$ $Z_{23} = 2.35$	H=1.35	H=4.93	H = 2.75	H=3.23	H=3.68	H=2.16	H = 0.62	H = 1.40	H = 4.05	H=4.36	H=2.30	H=3.71	H = 1.49	H=5.23	H=0.74	H = 0.22
		median	23.00	3.00	20.00	4.00	15.00	0.00	00.6	0.00	11.00	-1.00	-25.00	-3.00	-3.00	0.00	11.51	1.24	4.00	0.00
	subcortical (3) (N1 = 13; N2 = 17)	SD	19.26	10.07	31.65	14.93	20.11	10.73	13.60	8.29	11.78	8.19	16.83	69.6	1.80	1.27	4.00	-3.50	22.32	33.16
	5	Σ	26.85	0.76	21.23	2.94	19.46	1.18	11.69	0.82	7.23	0.24	-25.46	-3.41	-2.62	-0.65	19.24	1.79	12.31	-6.41
ic focus	2)	median	14.00	13.50	8.00	8.50	7.00	00.6	5.00	5.50	9.00	4.50	-11.00	-7.50	-2.00	-2.50	9.91	13.36	0.00	29.00
Localization of ischemic focus	back (2) (N1 = 13; N2 = 12)	SD	14.46	12.53	22.98	18.01	14.75	13.83	10.93	9.91	11.51	8.40	16.69	13.36	1.24	2.02	5.00	-12.50	30.68	34.17
Localiz		Σ	16.31	12.42	11.85	10.83	9.15	7.33	6.23	4.17	7.23	4.50	-13.54	-9.67	-2.23	-1.92	9.28	12.06	4.15	13.83
	(9	median	20.00	12.50	32.00	16.00	22.00	7.50	18.00	5.00	4.00	3.00	-24.00	-12.50	-3.50	-1.00	10.93	16.69	14.50	12.00
	front (1) (N1 = 19; N2 = 16)	SD	18.00	13.60	25.24	15.05	16.64	12.72	19.60	9.28	19.24	11.63	17.74	12.06	1.79	1.90	18.00	-24.00	29.86	26.18
		≥	23.42	10.81	23.16	14.31	18.47	8.56	17.89	5.50	4.89	2.69	-24.05	-11.00	-3.17	-1.44	19.60	17.74	14.50	13.44
	Group		-	7	-	2	-	2	-	2	-	2	-	2	-	7	-	2	-	7
	Variable			No. of errors in total	Perseverative	responses	Perseverative	errors	Percent of	perseverative errors	Non-	perseverative errors	Percentage of conceptual-	Percentage of conceptual-level responses Categories achieved responses Trials to complete the first category		first category	Failure to	focus		

H – ANOVA Kruskal-Wallis test; Z – U Mann-Whitney test; 1 – group rehabilitated in the hospital; 2 – group rehabilitated at home; M – mean; SD – standard deviation.

Adv Clin Exp Med. 2017;26(5):767–776

Table 5. The rating indicators in Trail Making Test (TMT B) and TMT B/A in patients rehabilitated in the hospital and at home depending on the location of ischemic focus

Variable					Localizati	on of ische	emic focus				Value	
	Group	front (1) (N1 = 19 ; N2 = 16)			(N1	back (2) (N1 = 13; N2 = 12)			subcortical (3) (N1 = 13; N2 = 17)			p < 0.05
		М	SD	median	М	SD	median	М	SD	median	test	
	1	126.00	131.20	113.00	90.54	96.28	57.00	101.92	57.63	87.00	TMTB	1
ТМТВ	2	39.00	59.33	37.50	13.25	30.65	7.50	48.53	56.80	50.00	H = 6.31 $W_{1.2} = 2.09$ $W_{1.3} = 0.38$ $W_{2.3} = 2.26$	0.043 0.036 0.705 0.024
D /A	1	0.57	0.82	0.30	0.58	1.19	0.60	0.28	0.72	0.30	H = 1.12	0.572
B/A	2	-0.10	0.76	0.01	0.03	0.50	-0.02	0.23	1.36	0.35	H = 0.44	0.799

 $H-ANOVA\ Kruskal-Wallis\ test;\ Z-U\ Mann-Whitney\ test;\ 1-group\ rehabilitated\ in\ the\ hospital;\ 2-group\ rehabilitated\ at\ home;\ M-mean;\ SD-standard\ deviation.$

Table 6. The rating indicators in Verbal Fluency Test (VFT) in patients rehabilitated in the hospital and at home depending on the location of ischemic focus

					Localizati	on of ische	emic focus					
Variable	Group	front (1) (N1 = 19 ; N2 = 16)			(N1	back (2) (N1 = 13; N2 = 12)			ubcortical = 13; N2 :	Value of the test	p < 0.05	
		М	SD	median	М	SD	median	М	SD	median	test	
F No. of	1	-3.37	2.87	-3.00	-2.69	2.02	-2.00	-1.85	2.23	-1.00	H = 2.60	0.271
words	2	-1.25	2.08	-1.50	-0.75	3.22	-1.00	0.23	1.36	0.35	H = 0.68	0.713
A No. of	1	-3.11	2.96	-2.00	-3.46	4.03	-4.00	-2.62	2.21	-2.00	H = 0.70	0.706
words	2	-2.06	2.21	-2.00	-2.17	2.95	-2.00	-1.00	4.08	-2.00	H = 0.45	0.798
S No. of	1	-2.05	2.50	-2.00	-2.38	2.38	-2.00	-2.85	2.42	-3.00	H = 0.88	0.644
words	2	-1.56	2.42	-1.50	-3.25	3.82	-3.50	-0.71	3.55	-1.00	H = 3.14	0.204
ZW No. of	1	-1.37	3.76	-2.00	-2.31	2.65	-2.00	-3.23	3.95	-3.00	H = 2.16	0.340
words	2	-1.13	3.95	-2.00	-0.58	4.34	-0.50	-1.35	3.20	-1.00	H = 0.21	0.903
O No. of	1	-2.42	2.59	-2.00	-2.00	2.70	-2.00	-3.46	2.99	-4.00	H = 2.45	0.294
words	2	-0.56	2.99	-1.00	-1.58	2.57	-1.00	-1.12	2.39	-1.00	H = 0.51	0.776
W No. of	1	-2.16	3.34	-2.00	-1.77	3.91	-2.00	-3.46	3.92	-3.00	H = 1.51	0.469
words	2	-1.50	3.92	-1.00	-1.00	2.45	-2.00	-0.06	3.31	-1.00	H = 1.25	0.535

 $H-ANOVA\ Kruskal-Wallis\ test;\ Z-U\ Mann-Whitney\ test;\ 1-group\ rehabilitated\ in\ the\ hospital;\ 2-group\ rehabilitated\ at\ home;\ M-mean;\ SD-standard\ deviation.$

more effectively use the strategy, thus providing more correct answers and completing a larger number of categories.

This improvement was observed in the basic components of the functions, such as starting operations, stopping the previous reaction, sustaining mental focus on the task and checking and self-monitoring activities.

Despite the fact that the persons with the front and subcortical lesion location showed higher executive dysfunction before the rehabilitation than those with the back location, their recovery indicators after rehabilitation were higher.

Probably the effects of the treatment were modified by the application of modern neurophysiological methods based on a broad multifaceted stimulation of the nervous system. The strategies based on neurophysiological methods are of particular importance, especially for people with cognitive impairment, including executive dysfunctions, when there are difficulties with the planning, execution and control of the activities.

Patients with subcortical lesion location rehabilitated at home obtained the smallest improvement in executive functions compared to those of other groups.

The total errors indicator showed a significantly lower improvement when compared to the persons with front and back lesion locations. The other indicators of Wisconsin Card Sorting Test (WCST) have not been modified by the location of stroke (p > 0.05). (Table 4).

The results of the study show that executive dysfunctions in patients with subcortical lesion location withdraw most slowly in rehabilitation. Therefore, this group of patients should be given special attention in determining the rehabilitation program.

In patients rehabilitated at home, the indicators of improvement in the ratio of trail making test B (TMT B) was significantly lower in patients with back lesion location of the stroke than in the group with the front and subcortical location (p < 0.05).

In the group rehabilitated at home, improvement in all the 3 lesion locations was significant only in the single indicator of verbal fluency test (VFT). Aphasia may have affected the results of the verbal fluency test (VFT) obtained in the compared groups.

Indicators of improvement in test categories and test letter of verbal fluency test (VFT) was not modified by the location of the stroke.

Executive dysfunctions may inhibit the process of treatment and rehabilitation after stroke. The patient forgetting or misunderstanding the issued instructions, their lack of insight, impaired awareness of the illness, impulsivity and aggression can reduce the effectiveness of physical therapy and may be the cause of the negative emotions from the physiotherapists.¹⁵

The problem of the patient's executive dysfunctions is faced by the family and carers who suffer from permanent stress and have to modify the emotional ties, to change their lifestyles and leisure activities. Patients' attempts to return to work usually fail.³

The psychosocial consequences of executive dysfunctions are sometimes more dramatic than motor problems and are the cause of permanent disability after stroke. The issue of cognitive dysfunctions should be included in the treatment of patients after stroke.

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