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**THE POTENTIAL OF THE KNOTT AND VOSS METHOD
FOR THE FUNCTIONAL RECOVERY OF STROKE
PATIENTS DURING THE ACUTE AND SUBACUTE
PHASE**

SUMMARY

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Graphs	11
Appendices	3

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TABLE OF CONTENTS

INTRODUCTION.....	5
1. WORKING HYPOTHESIS	6
2. OWN OBSERVATIONS	6
2.1. OBJECTIVE AND TASKS OF THE STUDY.....	6
2.2. SAMPLE AND ORGANIZATION OF THE STUDY.....	7
2.3. RESEARCH METHODS: FUNCTIONAL AND STATISTICAL	8
2.4. KINESITHERAPY METHODS	10
3. RESULTS AND ANALYSIS	12
4. CONCLUSION.	39
5. INFERENCES	40
6. RECOMMENDATIONS	41
7. CONTRIBUTIONS	42
8. PUBLICATIONS RELATED TO THE DISSERTATION WORK.....	43

USED ABBREVIATIONS

ADL – Activities of Daily Living

CHD – Coronary Heart Disease

MI – Myocardial Infarction

CVA – Cerebrovascular Accident (Stroke)

IP – Initial Position

LMSA – Left Middle Cerebral Artery Territory

RMSA – Right Middle Cerebral Artery Territory

LPMA – Left Anterior Cerebral Artery Territory

RPMA – Right Anterior Cerebral Artery Territory

RPSA – Right Posterior Cerebral Artery Territory

WHO – World Health Organization

EG – Experimental Group

CG – Control Group

CMN – Central Motor Neuron

PNF – Proprioceptive Neuromuscular Facilitation

SRRR – Round Table for Stroke Recovery and Rehabilitation

ISRR – International Stroke Recovery and Rehabilitation

Alliance

INTRODUCTION

The medico-social significance of stroke is determined by its high prevalence, the high mortality rate (ranking second in global mortality), severe disability and its impact on the independence and quality of life of patients and their families, as well as the substantial social costs. The forecast for the coming years is for this trend to intensify due to increased life expectancy. Modern treatment for acute stroke is still applied to only a small percentage of patients.

Management and the search for effective therapeutic interventions for post-stroke recovery are global health priorities.

There is indisputable evidence of the positive effect of applying kinesitherapy in the comprehensive treatment of stroke in all phases, with particular emphasis on the mandatory implementation of early kinesitherapy. Focusing on the early phase of recovery after a stroke has great potential that remains insufficiently achieved in clinical practice. The prognosis is favorable for patients who survive a stroke when they recover function within three months, unlike those with residual neurological deficits.

The high medical and social significance of stroke, the still unsatisfactory outcomes of the treatment and rehabilitation conducted, the undeniable need for sufficient and adequately directed physical activity for those affected, the necessity of stimulating and facilitating spontaneous motor function recovery, especially in the first 6 weeks after a stroke, has led us to study and refine the possibilities of kinesitherapy to achieve early motor activation of paretic segments and functions in acute and subacute stages, with a view to achieving independence and autonomy, thereby ensuring a better quality of life for patients.

1. WORKING HYPOTHESIS

By applying the comprehensive neurophysiological method of Knott and Voss, based on the normal sequence of motor development in humans, the philosophy and principles of PNF, and adapted for clinical conditions in the acute and subacute stages of stroke, when the processes of self-recovery are most pronounced, it is possible, within the framework of comprehensive treatment, to achieve effective prevention of hypokinetic syndrome, early appropriate targeted motor activation, leading to optimal functional recovery, independence, and autonomy for stroke survivors, thus improving the quality of life for them and their families.

2. OWN OBSERVATIONS

2.1. OBJECTIVE AND TASKS OF THE STUDY

Objective of the Study

To track the effect of the comprehensive Knott and Voss methodology, adapted for clinical settings, on early motor activation and functional recovery in stroke patients during the acute and subacute stages.

To achieve this goal, we set the following **tasks**:

1. Develop and implement a kinesitherapy program based on the comprehensive Knott and Voss methodology for stroke patients in the acute and subacute stages, adapted for clinical settings through a critical analysis of available literature and advancements in brain reorganization and plasticity.

2. Assess the potential of the neurophysiological comprehensive methodology in comparison with standard kinesitherapy intervention regarding:

- a) Recovery of global function;
- b) Functional recovery of the neck and torso;
- c) Functional recovery of the lower limb;
- d) Functional recovery of the upper limb;
- e) Restoration of locomotion;
- f) Recovery of autonomy and independence for patients.

3. Determine if there is a dependency of paretic limb recovery on the recovery of the torso and neck and how this is influenced by the kinesitherapy programs applied.

4. Select appropriate methods for organizing and studying the cohort of patients under observation.

5. Investigate the potential of the Knott and Voss methodology for maximizing early motor activation - within the first days post-stroke diagnosis - and compare it with the typically more passive kinesitherapy approach in the same timeframe.

6. Explore the possibility of predicting motor recovery based on the lesion's location.

7. Study and evaluate the significance of the "time" factor in its various aspects (the time window of spontaneous recovery and duration of the kinesitherapy program) to optimize the recovery of motor function, self-care, and independence in stroke patients.

2.2. SAMPLE AND ORGANIZATION OF THE STUDY

The study was conducted at St. Anna University Hospital in Sofia over a five-year period. It included 318 stroke patients in the acute and subacute phases (Table 1.). The patients were randomly assigned into two groups (non-intentionally). Group A – experimental (EG), consisting of 143 patients who underwent the comprehensive kinesitherapy method of Knott and Voss. Group B – control (CG), consisting of 175 patients who received the standard kinesitherapy intervention used at the medical institution. The average number of sessions was 15-18, conducted twice a day with a duration of 40-70 minutes.

Table 1. General characteristics of the monitored patients

Group	A	B
Number of patients	143	175
Age	59±11,4	61,7±11,6
Type of stroke	Ischemic - 83,9% Hemorrhagic -16,1%	Ischemic - 84,6% Hemorrhagic – 15,4%
Localization (hemisphere)	Right - 46,9% Left - 53,1%	Right - 47,5% Left - 52,5%
Presence of aphasia	25,9%	36,6%
Applied method	Knott and Voss	Standard method

2.3. RESEARCH METHODS

FUNCTIONAL

To objectively assess the condition and track the progress of motor function recovery in the patients of our study, we applied six tests. These tests were used to track both the general and detailed progression.

1. Brunnstrom Test

This provides quick, general information on the state of motor function. Developed by Signe Brunnstrom, it is based on muscle tone, possible movements, and pathological synkineses. It includes six consecutive stages through which recovery progresses in stroke patients, from Stage I to VI. These stages are not mandatory and depend on the size of the lesion and its localization.

2. Functional Assessment of Movements in Central Motor Neuron (CMN) Lesions Test

Through this, fundamental movements are assessed, providing information about the motor function of individual segments – neck, torso, upper and lower limbs. We used a six-point scale for a more detailed evaluation with a progression from 0 to 5 according to Kostadinov D: Degree 0 – No movement. Degree 1 – The patient performs a small part of the indicated movement. Degree 2 – Performs $\frac{1}{2}$ of the movement. Degree 3 – Performs the movement almost to its full range. Degree 4 – Performs 80-90% of the indicated movements. Degree 5 – The patient performs everything like a healthy person.

3. Michels upper limb test

Four basic movements of the arm are assessed: hand-to-mouth, lifting the arm forward to horizontal, hand above the head, and hand behind the back in important positions of pronation and supination. These movements are performed in three variants: reaching the target, gripping the fingers in the final position, and gripping and releasing the fingers in the final position – assessed using the six-point scale of Kostadinov D.

4. Rivermead (RMA) test

For evaluating motor function in stroke patients, we tested and

implemented the Rivermead motor assessment (RMA) for the first time in Bulgaria.

This test evaluates motor function in detail. Through 38 motor tasks, varying in difficulty, the global function, leg and torso function, and arm function are assessed. Two ratings are given: 1 – if the patient can perform the activity within the required time, and 2 – if the patient cannot. Three attempts are allowed.

5. Locomotion test

This test evaluates the ability of stroke patients to walk independently. It includes five stages: Stage 0 – no independent walking, even with assistance; Stage 1 – the patient takes a few steps with the help of another person; Stage 2 – the patient moves with assistance over smooth terrain; Stage 3 – the patient walks independently up to 1500 meters and uses standard stairs; Stage 4 – the patient's walking, although slightly limited, allows for social reintegration.

6. Self-Care and Independence Test

This includes 6 stages progressing from: Stage 0 – complete dependence on external help; Stage 1 – early signs of self-care; Stage 2 – minimal self-care; Stage 3 – good self-care; Stage 4 – very good self-care and independence with minor deficits; Stage 5 – complete self-care and independence.

STATISTICAL METHODS

We applied the following statistical methods:

- **Descriptive statistics:** variance and alternative analysis.
- **Comparative statistics through hypothesis testing:**

Student's t-test for dependent and independent samples; Mann-Whitney χ^2 -test with U-test for independent samples; McNemar χ^2 -test for dependent samples; Wilcoxon Test.

- **Correlation analysis:** Non-parametric Spearman correlation with “ ρ ” coefficient; Kendall's “ τ ” coefficient for dependencies between the examined parameters.

The selected confidence level is $P = 99\%$ or significance level $\alpha = 0.01$.

Statistically significant results are for $**p < 0.01$ or $***p < 0.001$.

2.4. KINESITHERAPY METHODS

Comprehensive method of Knott and Voss

The method is based on the necessity that after injury, the patient's recovery must follow the sequence of normal motor development in humans. Maximum peripheral stimulation is used to achieve motor responses.

The therapy is carried out through:

- Application of the main PNF techniques for facilitation.
- Following the sequence of normal motor development.

Mc Graw and Gesell adapted the Comprehensive gymnastics as exercises on a mat. These include progressing from basic exercises and positions to more complex ones (turning from a supine position to sitting, and vice versa, moving to sitting, standing, and walking).

These exercises can be adapted and applied in other settings – on the patient's bed during clinical treatment and at home, on a massage table, on an appropriate mat on the floor, etc.

We adapted the comprehensive Knott and Voss methodology for application in clinical settings.

The methodology consists of comprehensive movement and position patterns, in which the patterns and techniques of PNF are used with high precision.

The goal of the applied kinesitherapy program is to achieve maximal early motor activation and optimal functional recovery of patients with stroke.

- Therapeutic tasks

Based on functional assessment, the primary and specific tasks are determined.

- Primary tasks

The primary tasks include functional activities that change as the patient masters them.

- Specific tasks

Specific tasks are set for each therapeutic tool and for each kinesitherapy procedure. These can be summarized in the following directions: favorable psycho-emotional influence; prevention of complications; improvement of muscle tone; activation, unlocking,

and strengthening of motor responses; improvement of motor and postural control; suppression of pathological synkinesias and restoration of physiological synergies; restoration of global movements, central stability, functionality of the neck and torso, and distal movements, balance, coordination, and sensory function, normal gait, and ADL.

Comparison of the applied kinesitherapy methods

The kinesitherapy programs of the two observed groups were conducted according to all kinesitherapy principles for stroke patients, with respect to individual approach, load, and recovery in cases of CMN damage.

The focus of the standard kinesitherapy program in the CG was prevention, step-by-step verticalization, and functional recovery. The appropriate methods were applied according to the tasks – positional therapy, passive, passive-active, active techniques, stepwise verticalization, and walking training. Elements of specialized methods, including PNF, were included, but only partially, such as spiral-diagonal patterns for the limbs with a focus on the upper limb, and this was done passively or passively-active. ***The lack of an integrated approach, including the possible and adapted PNF techniques, limited early motor activation in stroke patients.***

The focus of the EG was early motor activation and optimal functional recovery. It also included tasks valid for the CG.

The main difference between the two applied kinesitherapy programs is their ability for early motor activation. While the standard kinesitherapeutic program focuses on passive and passive-active methods to achieve the goal, the Knott and Voss Comprehensive method emphasizes early motor activation of patients. This is supported by the philosophy of PNF with its integrative, positive approach, working without pain or fatigue, and achieving functional recovery. Additionally, the skillful application of proven effective PNF techniques contributes to this. Finally, a strong aspect is the **progression of the kinesitherapy program in line with the sequence of normal motor development**, which includes teaching functional activities from the beginning of treatment, such as: turning in bed, moving from supine to sitting with

legs down (without mastering this, the patient remains dependent on others), standing, balance, and walking. Permanent results are achieved in both restored movements and motor functions. A key tool is training *in global movement patterns, which is the way to support and enhance movements, as the person controls them within patterns, rather than as isolated muscle actions.*

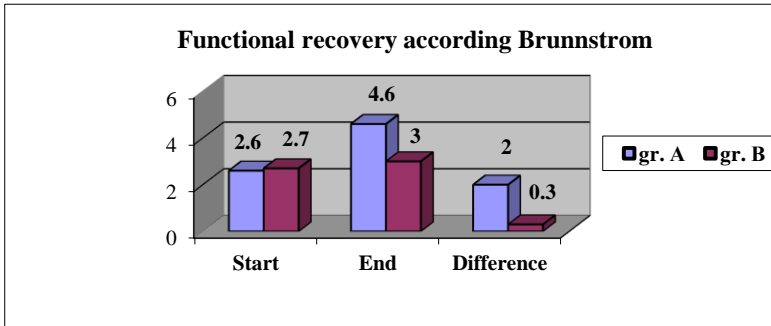
3. RESULTS AND ANALYSIS

• Effect of kinesitherapy on functional recovery using Brunnstrom

Table 2. Functional recovery using Brunnstrom (Progression)

Stage	Group A				Group B			
	Start		End		Start		End	
	Number of patients	%	Number of patients	%	Number of patients	%	Number of patients	%
I	13	9,1	-	-	22	12,6	3	1,7
I-II	9	6,3	-	-	19	10,9	17	9,7
I-III	-	-	-	-	-	-	1	0,6
II	42	29,4	-	-	30	17,1	17	9,7
II-III	4	2,8	-	-	3	1,7	13	7,4
II-IV	-	-	-	-	2	1,1	-	-
III	27	18,9	2	1,4	23	13,1	31	17,7
III-IV	8	5,6	4	2,8	17	9,7	25	14,3
III-V	-	-	-	-	-	-	1	0,6
IV	40	28,0	44	30,8	49	28,0	40	22,9
IV-V	-	-	17	11,9	9	5,1	13	7,4
V	-	-	39	27,3	1	0,6	14	8,0
V-VI	-	-	14	9,8	-	-	-	-
VI	-	-	23	16,1	-	-	-	-
Total	143	100	143	100	175	100	175	100

At the beginning of the treatment in EG, the relative proportion of patients in stage II is the highest at 29.4%, followed by stage IV at 28.0%. In CG, the highest relative proportion is in stage IV at 28.0%, followed by stage II at 17.1%. At the end of the treatment course, in EG: 30.8% are in stage IV, and a total of 65.1% have progressed from stage IV to V, V to VI according to Brunnstrom. In CG, the largest relative proportion of patients is in stage IV at 22.9%, while 15.4% are in higher stages IV to V and V, with a total of 61.1% progressing from stages I to III to stage IV (Table 2).



*Statistically significant difference *** $p < 0.001$, ** $p < 0.0$*

Figure 1. Functional recovery using Brunnstrom

Figure 1. shows the results – average values of functional recovery using Brunnstrom. The final examination shows improvement in both groups at a high significance level of $\alpha = 0.001$. The difference in improvement is 6.81 points at $\alpha = 0.001$ in favor of the EG, where patients progressed through two stages, while those in the CG progressed by 0.3 stages. The initiation and enhancement of movements from the center to the periphery using the Knott and Voss methodology leads to the normalization of muscle tone and the establishment of correct movement patterns.

- **Effect of kinesitherapy on functional recovery in CMN damage**

- Functional recovery of the neck and torso in CMN damage

Table 3. Functional recovery of the neck and torso in CMN damage

Parameter	Group	Start		End		Difference d	t	p
		\bar{X}_H	S_H	\bar{X}_K	S_K			
1 - A NECK Flexion from full extension	A	3,3287	0,970	4,8951	0,350	1,5664	21,18	***
	B	3,5086	1,129	4,1371	0,880	0,6286	14,06	***
	Difference	- 0,1799		0,7580		0,9379		
	t	- 1,51		9,69		11,28		
	p	**		***		***		
2 Extension from full flexion	A	2,6853	0,960	4,6923	0,714	2,0070	29,66	***
	B	3,0171	1,229	3,5543	0,081	0,5371	12,58	***
	Difference	- 0,3318		1,1380		1,4699		
	t	- 2,64		10,58		19,02		
	p	***		***		***		
3 Turning to the side	A	2,7483	0,982	4,7552	0,608	2,0070	27,15	***
	B	3,0857	1,188	3,6514	1,016	0,5657	13,56	***
	Difference	- 0,3375		1,1038		1,4413		
	t	- 2,72		11,42		17,20		
	p	***		***		***		
22 D - Body Sitting from a supine position	A	1,3007	1,151	4,6014	0,583	3,3007	33,09	***
	B	1,7657	1,481	2,9143	1,093	1,1486	11,31	***
	Difference	- 0,4650		1,6871		2,1521		
	t	- 3,07		16,63		14,94		
	p	***		***		***		
23 Turning to the side and returning.	A	2,0070	1,010	4,8042	0,479	2,7972	33,09	***
	B	2,4114	1,361	3,0514	1,100	0,6400	10,45	***
	Difference	- 0,4044		1,7528		2,1572		
	t	- 2,95		17,73		21,12		
	p	***		***		***		
24 Body rotation and return	A	1,9860	1,028	4,7762	0,536	2,7902	32,72	***
	B	2,4686	1,604	3,0171	1,091	0,5486	6,88	***
	Difference	- 0,4826		1,7591		2,2416		
	t	- 3,11		17,62		19,14		
	p	***		***		***		
25 Forward bending at the hips and return	A	1,6993	1,035	1,6993	0,459	3,1119	34,19	***
	B	2,3200	1,513	2,3200	1,046	0,9486	10,33	***
	Difference	- 0,6207		1,5426		2,1633		
	t	- 4,17		16,39		16,55		
	p	***		***		***		
26 "Marching"	A	1,3566	1,313	4,3706	0,728	3,0140	30,52	***
	B	1,5429	1,604	2,4914	1,389	0,9486	13,06	***
	Difference	- 0,1862		1,8792		2,0654		
	t	- 1,12		14,62		17,20		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The final results presented in table 3. indicate an improvement in both groups with a high level of significance for all parameters at $\alpha = 0.001$. The improvement is particularly significant in Group A, as evidenced by the difference d. When comparing the differences between Group A and Group B, a credible difference of 2.2 degrees was observed in favor of Group A for

the indicators critical for self-care: rotations, forward torso tilt, and transitioning from lying to sitting position. Without these abilities, the patient remains effectively dependent on external assistance.

• **Functional recovery of the lower limb in CMN damage**

Table 4. Functional recovery of the lower limb in CMN damage

Parameter	Group	Start		End		Difference d	t	P
		\bar{X}_H	S_H	\bar{X}_K	S_K			
14 G Lower limb Heel lift to the knee	A	2,6224	1,099	4,8252	0,449	2,2028	26,37	***
	B	2,8343	1,175	3,5771	0,075	0,7429	18,44	***
	Difference	- 0,1104		1,7030		1,8135		
	t	- 0,77		11,93		20,88		
	p	**		***		***		
15 Getting up from a seated position	A	1,1189	1,172	4,6224	0,614	3,5035	30,47	***
	B	1,4914	1,422	2,9257	1,179	1,4343	13,55	***
	Difference	- 0,3725		1,6967		2,0692		
	t	- 2,51		15,56		13,45		
	p	**		***		***		
16 Extension from flexion with a heel strike	A	1,3497	1,218	3,9091	0,804	2,5594	30,47	***
	B	1,4629	1,342	1,9714	1,324	0,5086	9,27	***
	Difference	- 0,1132		1,9377		2,0509		
	t	- 0,78		15,34		21,10		
	p	**		***		99,995		
17 Standing on toes alternately	A	1,0210	1,091	3,3986	0,723	2,3776	29,31	***
	B	1,1429	1,235	1,4571	1,272	0,3143	6,98	***
	Difference	- 0,1219		1,9415		2,0633		
	t	- 0,92		16,23		23,28		
	p	**		***		***		
18 Standing on heels alternately	A	0,7972	1,059	2,9720	0,919	2,1748	29,73	***
	B	0,9029	1,168	1,1829	1,269	0,2800	6,46	***
	Difference	- 0,1057		1,7892		1,8948		
	t	- 0,84		14,11		23,20		
	p	**		***		***		
19 Side step to the left	A	1,042	1,411	4,7343	0,593	2,9301	25,44	***
	B	2,0114	1,675	2,9714	1,387	0,9600	12,97	***
	Difference	- 0,2072		1,7628		1,9701		
	t	- 1,18		14,17		14,88		
	p	**		***		***		
20 Side step to the right	A	1,7902	1,398	4,7203	0,621	2,9301	25,26	***
	B	1,9943	1,676	2,9200	1,400	0,9257	12,77	***
	Difference	- 0,2041		1,8003		2,0044		
	t	- 1,16		14,27		15,18		
	p	**		***		***		
21 Balancing on one leg	A	1,0979	1,140	3,6573	0,770	2,594	29,46	***
	B	1,9943	1,676	2,9200	1,400	0,9257	12,77	***
	Difference	- 0,2041		1,8003		2,0044		
	t	- 1,16		14,27		15,18		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The results shown in table 4. reveal an improvement in lower limb function in both observed groups at $\alpha = 0.001$, with a more pronounced effect in Group A. The most significant improvement, 4.82, was seen in the "Heel to knee lift" indicator. The application of specific PNF (Proprioceptive Neuromuscular Facilitation) techniques within the comprehensive methodology enhances muscle tone, the sequential alternation of antagonists, and facilitates as well as strengthens distal movements.

• **Functional recovery of the upper limb in CMN damage.**

Table 5. Functional recovery of the upper limb in CMN damage

Parameter	Group	Start		End		Difference d	t	P(t)
		\bar{X}_H	S_H	\bar{X}_K	S_K			
4 - B Upper limb (from sitting) Lateral transfer upward	A	2,4685	1,299	4,6923	0,560	2,2238	24,99	***
	B	2,5657	1,577	3,2171	1,401	0,6514	14,02	***
	Разлика	- 0,0972		1,4752		1,5724		
	t	- 0,59		11,84		15,66		
	p	**		***		***		
5 Bringing the hand to the mouth	A	2,4476	1,336	4,7133	1,603	2,2657	24,21	***
	B	2,5714	0,552	3,2343	1,433	0,6629	13,53	***
	Разлика	- 0,1239		1,4790		1,6029		
	t	-0,74		1,65		15,95		
	p	**		***		***		
6 Lateral transfer with elbow extension	A	1,6923	1,450	4,000	0,964	2,3077	28,57	***
	B	1,8286	1,529	2,2286	1,559	0,4000	9,87	***
	Разлика	- 0,1363		1,7714		1,9077		
	t	- 0,81		11,86		22,27		
	p	**		***		***		
7 Arm behind the back	A	1,5175	1,467	3,8741	0,941	2,3566	29,14	***
	B	1,6400	1,517	1,9257	1,489	0,2857	7,22	***
	Разлика	- 0,1225		1,9484		2,0709		
	t	- 0,73		13,58		24,31		
	p	**		***		***		
8 Pronation/supination	A	2,2168	1,459	4,3007	0,779	2,0839	23,70	***
	B	2,2743	1,577	2,7543	1,554	0,4800	11,65	***
	Разлика	- 0,0575		1,5464		1,6039		
	t	- 0,33		10,84		17,51		
	p	**		***		***		
9 Grasping and holding - standard objects	A	2,0490	1,479	4,08339	0,868	2,0350	23,61	***
	B	2,0914	1,566	2,588	1,532	0,4971	11,62	***
	Разлика	- 0,0425		1,4953		1,5378		
	t	- 0,25		10,39		16,87		
	p	99,20%		99,99%		99,99%		
10 Pinching - Thumb opposition with	A	1,9860	1,552	3,9650	1,051	1,9790	21,96	***
	B	2,0514	1,616	2,52,57	1,575	0,4743	11,52	***
	Разлика	- 0,0654		1,4393		1,5047		

index finger	t	- 0,37		9,36		16,47		
	p	99,29%		99,99%		99,99%		
11 Straightening the fingers and wrist to neutral	A	1,4266	1,475	3,5594	1,059	2,1329	27,69	***
	B	1,6286	1,495	1,9429	1,526	0,3143	8,49	***
	Разлика	- 0,2020		1,6166		1,8186		
	t	- 1,21		10,73		22,52		
	p	**		***		***		
12 - B Dexterity Buttoning buttons – various	A	0,9371	1,252	2,7972	1,225	1,8601	28,72	***
	B	1,0343	1,241	1,2686	0,097	0,2343	6,69	***
	Разлика	- 0,0972		1,5286		1,6259		
	t	- 0,69		10,81		23,16		
	p	**		***		***		
13 Writing	A	1,0210	1,253	3,1259	1,180	2,1049	26,37	***
	B	1,1314	1,278	1,4229	1,332	0,2914	6,67	***
	Разлика	- 0,1104		1,7030		1,8135		
	t	- 0,77		11,93		20,88		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The results in table 5. demonstrate an improvement in upper limb function at $p > 0.001$ across all studied indicators in both groups, with a significant improvement in group A. The indicators with the highest values are "Upward transfer" and "Hand-to-mouth." These outcomes result from the applied global models supplemented with PNF (Proprioceptive Neuromuscular Facilitation) techniques.

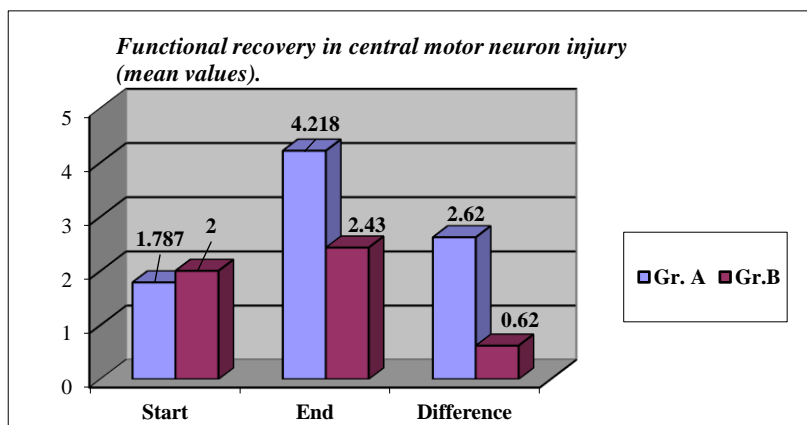


Figure 2. Functional recovery in central motor neuron injury (mean values).

The results from figure 2. show a significant improvement ($d = 1.81$) in patients in group A compared to group B at $p < 0.001$. The Knott and Voss methodology demonstrates high effectiveness in kinesitherapy for central motor neuron injury, particularly when

applied systematically and intensively.

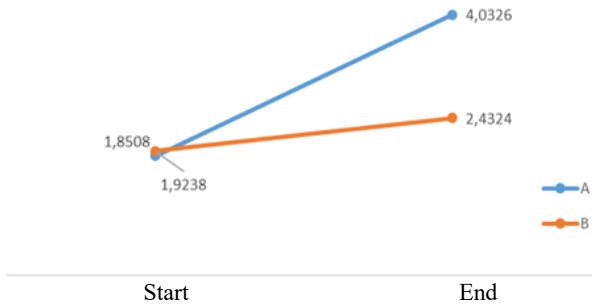
• Influence of kinesitherapy on the functional recovery of the upper limb according to Michels

Table 6. Recovery of "Hand-to-mouth" movement
Michels test for upper limb

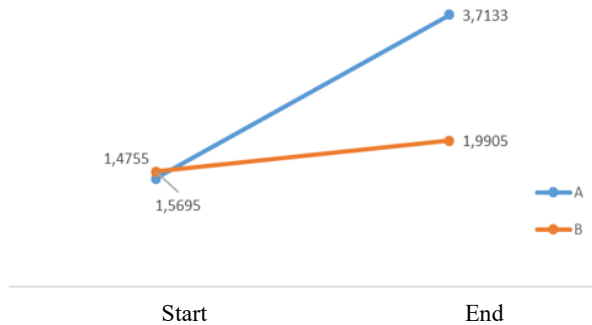
Parameter	Group	Start		End		Difference d	t	P
		\bar{X}_H	S_H	\bar{X}_K	S_K			
1. Hand-to-mouth (the hand is in supination) a) to touch and return -S, E	A	1,9231	1,343	4,2378	0,769	2,3147	29,78	***
	B	2,0171	1,499	2,5657	1,476	0,5486	12,87	***
	Difference	- 0,0941		1,6720		1,7661		
	t	- 0,58		12,26		20,86		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	1,2587	1,377	3,4685	1,125	2,2098	30,34	***
	B	1,3429	1,312	1,7029	1,431	0,3600	8,86	***
	Difference	- 0,0841		1,7657		1,8498		
	t	- 0,56		12,02		23,20		
	p	**		***		***		
c) to grasp and release in the final position -S, E	A	1,2448	1,375	3,4336	1,142	2,1888	30,60	***
	B	1,3486	1,295	1,7029	1,407	0,3543	8,92	***
	Difference	- 0,1038		1,7307		1,8345		
	t	- 0,69		11,86		23,47		
	p	**		***		***		
2. Hand-to-mouth (the hand is in pronation) a) to touch and return -S, E	A	2,4965	1,316	4,7343	0,530	2,2378	24,18	***
	B	2,6000	1,601	3,2914	1,394	0,6914	13,72	***
	Difference	- 0,1035		1,4428		1,5463		
	t	- 0,62		11,70		15,38		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	1,5455	1,408	3,7203	0,974	2,1748	30,30	***
	B	1,6000	1,369	2,0286	1,468	0,4286	10,49	***
	Difference	- 0,0549		1,6917		1,7463		
	t	- 0,35		11,82		22,08		
	p	**		***		***		
c) to grasp and release in the final position - S, E	A	1,5105	1,388	3,6434	0,967	2,1329	30,63	***
	B	1,5714	1,354	1,9771	1,426	0,4057	9,99	***
	Difference	- 0,0609		1,6662		1,7272		
	t	- 0,39		11,91		22,34		
	p	***		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

Both groups show an improvement in movement at a significance level of $\alpha = 0.001$ ***, with the improvement being significantly higher in the patients from the experimental group (EG), as evident from the differences in growth at $\alpha = 0.001$ ***.



Graph 1. Hand in *pronation* (mean values)



Graph 2. Hand in *supination* (mean values)

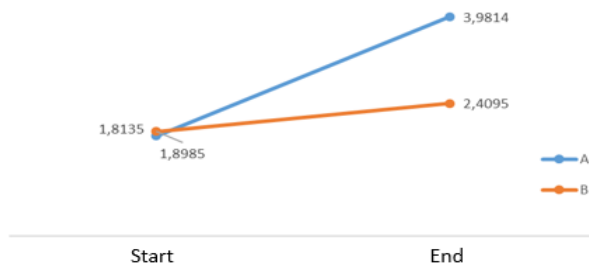
The results from graphs 1. and 2. indicate that for the "Hand-to-mouth" movement, both the initial and final assessments in both groups have higher values with the hand in pronation. The improvement is significant in the experimental group (EG), with an average increase of 2.2 points compared to only 0.3 points in the control group. Particularly noteworthy is the improvement in the "Hand in supination" position in the EG, which provides a solid foundation for performing daily activities. The Knott and Voss methodology results in achieving good static control of the proximal segments, improved muscle tone, and the ability for smooth antagonist transition.

Table 7. Recovery of the Movement - "Lifting the arm forward to horizontal position" (Shoulder flexion to 90°) Michels test for upper limb

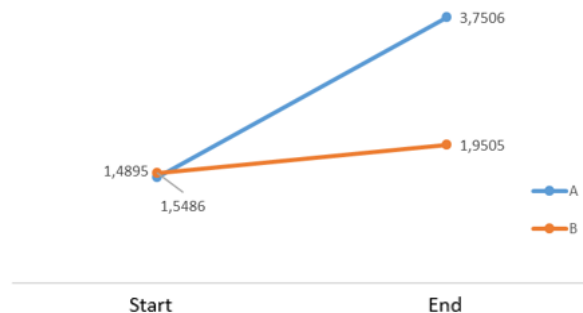
Parameter	Group	Start		End		Difference d	t	P
		\bar{X}_H	S_H	\bar{X}_K	S_K			
3 Fl. in sh. joint 90° (arm in supination) a) to touch and return -S, E	A	1,8951	1,372	4,2587	0,802	2,3636	29,88	***
	B	1,9771	1,489	2,4971	1,508	0,5200	11,95	***
	Разлика	- 0,0820		1,7616		1,8436		
	t	- 0,51		12,59		21,39		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	1,2937	1,383	3,5245	1,137	2,2308	30,39	***
	B	1,3429	1,294	1,6914	1,417	0,3486	8,62	***
	Разлика	- 0,0492		1,8330		1,8822		
	t	- 0,33		12,52		23,53		
	p	**		***		***		
c) to grasp and release in the final position -S, E	A	1,2797	1,381	3,4685	1,143	2,1888	29,75	***
	B	1,3257	1,279	1,6629	1,379	0,3371	8,57	***
	Разлика	- 0,0460		1,8057		1,8517		
	t	- 0,31		12,53		23,30		
	p	**		***		***		
4 Fl. in sh. joint 90° (arm in pronation) a) to touch and return -S, E	A	2,4056	1,344	4,6503	0,631	2,2448	24,50	***
	B	2,5086	1,601	3,1429	1,437	0,6343	13,77	***
	Разлика	- 0,1030		1,5074		1,6105		
	t	- 0,61		11,66		16,57		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	1,5175	1,378	3,6643	0,985	2,1469	30,61	***
	B	1,5862	1,369	2,0971	2,154	0,5230	4,17	***
	Разлика	- 0,0687		1,5672		1,6239		
	t	- 0,44		8,04		10,66		
	p	**		***		***		
c) to grasp and release in the final position -S, E	A	1,5175	1,378	3,6294	0,991	2,1119	31,01	***
	B	1,5771	1,358	1,9886	1,422	0,4114	9,92	***
	Разлика	- 0,0597		1,6408		1,7005		
	t	- 0,39		11,67		22,15		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The results from table 7. show an improvement in both groups at $\alpha = 0.001$, with the improvement being significantly higher in the patients from the experimental group (EG), as indicated by the differences in gains at $\alpha = 0.001$ ***.



*Graph 3. Hand in **pronation** (mean values)*



*Graph 4. Hand in **supination** (mean values)*

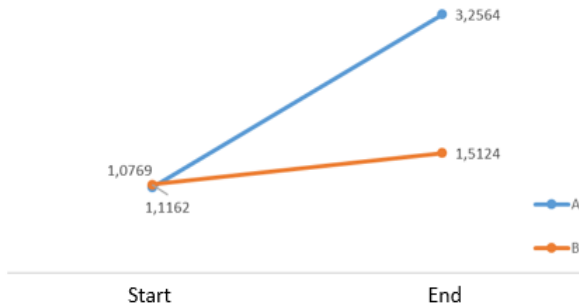
The results from graphs 3. and 4. show higher values for performing the movement in pronation compared to supination. The improvement favors the experimental group (EG). The focus on recovery from the center to the periphery, as per the Knott and Voss methodology, enhances the contractility of the neck and torso muscles and the stability of the shoulder girdle, leading to improved distal movements, including finger extension.

Table 8. Recovery of the movement – "The arm over the head"
Michels test for upper limb

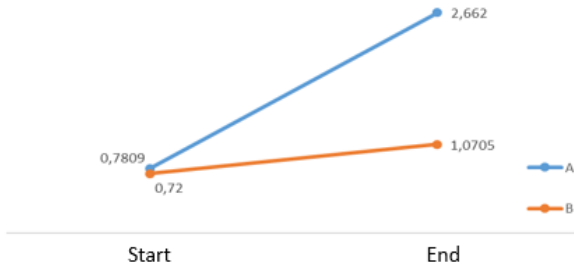
Parameter	Group	Start		End		Difference d	t	P
		\bar{X}_H	S_H	\bar{X}_K	S_K			
5 The hand above the head in soup. a) to touch and return S, E	A	0,9650	0,996	3,1399	1,142	2,1748	37,97	***
	B	1,071	1,014	1,4114	1,141	0,3943	10,17	***
	Difference	- 0,0521		1,7284		1,7805		
	t	- 0,46		13,44		26,48		
	p	**		***		***		
b) to open the fingers of the hand in the final position –S, E	A	0,6993	0,920	2,4336	1,461	1,7343	22,96	***
	B	0,5943	0,796	0,9143	0,958	0,3200	8,82	***
	Difference	0,1050		1,5193		1,4143		
	t	1,09		11,14		17,86		
	p	**		***		***		
c) to grasp and release in the final position –S, E	A	0,6783	0,901	2,4126	1,455	1,7343	22,57	***
	B	0,5486	0,771	0,8857	0,921	0,3371	9,18	***
	Difference	0,1298		1,5269		1,3971		
	t	1,38		11,37		17,36		
	p	**		***		***		
6 The hand above the head (in pron.) a) to touch and return – S, E	A	1,4196	1,171	3,8182	0,861	2,3986	35,58	***
	B	1,5029	1,313	1,9600	1,395	0,4571	9,71	***
	Difference	- 0,0833		1,8582		1,9415		
	t	- 0,59		13,91		24,23		
	p	**		***		***		
b) to open the fingers of the hand in the final position –S, E	A	0,9371	1,056	3,0070	1,207	2,0699	32,71	***
	B	0,9486	0,948	1,3086	1,118	0,3600	9,66	***
	Difference	- 0,0115		1,6984		1,7099		
	t	- 0,10		13,00		24,25		
	p	**		***		***		
c) to grasp and release in the final position –S, E	A	0,8741	1,020	2,9441	1,232	2,0699	32,32	***
	B	0,8971	0,904	1,2686	1,062	0,3714	9,90	***
	Difference	- 0,0230		1,6755		1,6985		
	t	- 0,21		13,02		23,85		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

Table 8. presents the results for the challenging recovery movement – "Arm overhead." The difference in improvement favors the experimental group (EG) at $p < 0.001$.



Graph 5. Hand in *pronation* (mean values)



Graph.6. Hand in *supination* (mean values)

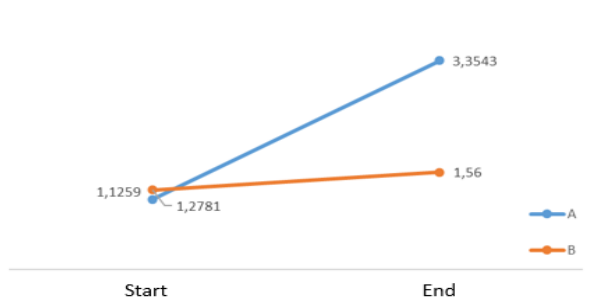
The results from the mean values of the three variants for the movement "Arm overhead" (graphs 5. and 6.) indicate a significantly higher improvement in the experimental group (EG), particularly in the position "Hand in supination" with an increase of 1.55 points. The improvement in the control group (CG) is 0.35 points, while in the EG, it is 1.88 points.

Table 9. Recovery of the movement - "Arm behind the back"

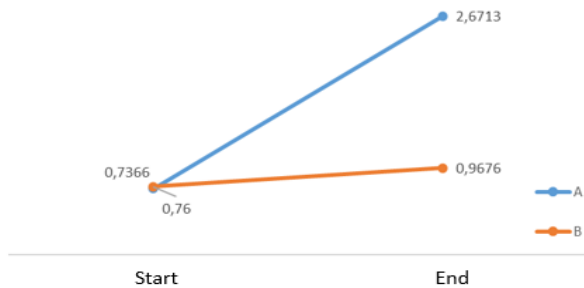
Parameter	Group	Start		End		Difference d	t	P
		\bar{X}_H	S_H	\bar{X}_K	S_K			
7 The arm behind the back (in supination) a) to touch and return - S, E	A	0,9021	1,083	3,1608	1,130	2,587	38,63	***
	B	1,0229	1,093	1,2229	1,105	0,2000	6,60	***
	Разлика	- 0,1208		1,9380		2,0587		
	t	- 0,98		15,40		32,89		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	0,6573	0,958	2,4476	1,336	1,7902	27,24	***
	B	0,6343	0,853	0,8457	0,893	0,2114	6,83	***
	Разлика	0,0231		1,618		1,5788		
	t	0,23		12,76		23,03		
	p	**		***		***		
c) to grasp and release in the final position -S, E	A	0,6503	0,959	2,4056	1,341	1,7552	26,90	***
	B	0,6229	0,848	0,8343	0,878	0,2114	6,83	***
	Разлика	0,275		1,5713		1,5438		
	t	0,27		12,54		22,64		
	p	**		***		***		
8 The hand behind the back (in pronation) a) to touch and return - S, E	A	1,4056	1,410	3,8182	0,997	2,4126	30,55	***
	B	1,6229	1,522	1,9143	1,435	0,2914	7,33	***
	Разлика	- 0,2173		1,9039		2,1212		
	t	- 1,31		13,10		25,30		
	p	**		***		***		
b) to open the fingers of the hand in the final position -S, E	A	0,9930	1,270	3,1399	1,208	2,1469	33,80	***
	B	1,1086	1,220	1,3943	1,227	0,2857	7,72	***
	Разлика	- 0,1156		1,7456		1,8611		
	t	- 0,83		12,71		26,40		
	p	**		***		***		
c) to grasp and release in the final position -S, E	A	0,9790	1,275	3,1043	1,243	2,1259	32,72	***
	B	1,1029	1,213	1,3714	1,201	0,2686	7,57	***
	Разлика	- 0,1238		1,7335		1,8573		
	t	- 0,88		12,61		26,29		
	p	**		***		***		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

Table 9. shows the results of the study on the test movement 'Hand behind the back.' This movement is sometimes unattainable for patients who have experienced a stroke. Patients in the experimental group (EG) show greater improvement with *** $p < 0.001$.



Graph 7. hand in *pronation* (mean values)



Graph 8. Hand in *supination* (mean values)

7. and 8. show that the trend of achieving higher results with the pronated hand is maintained, with a greater improvement in the experimental group (EG) reflecting a difference in gains of 2.12 points.

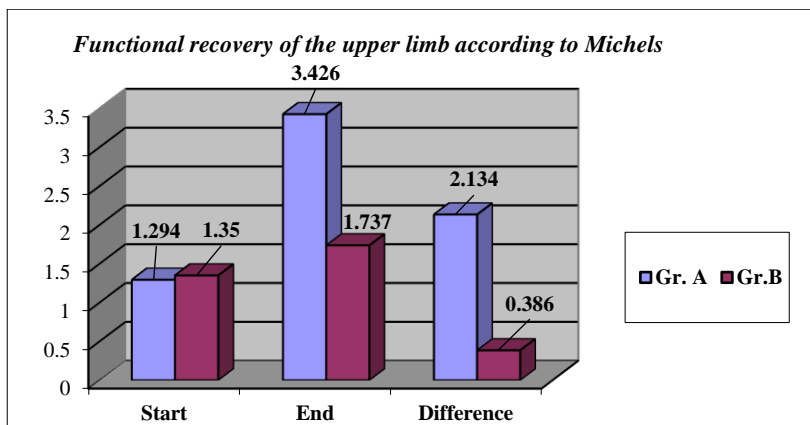


Fig. 3. *Functional recovery of the upper limb according to Michels*

Figure 3. presents the mean values of the results from all indicators of the Michels test for the upper limb. Improvement is observed in both studied groups. The difference in improvement is 1.748 at a significance level of $\alpha = 0.001$ in favor of the experimental group (EG). This is attributable to the philosophy, principles, and comprehensive methodology of Knott and Voss. Movements that are challenging to achieve in patients with cerebral stroke are being successfully restored.

• **Influence of kinesitherapy on the recovery of motor function according to Rivermead (RMA).**

To assess motor function in patients following a cerebral stroke, we tested and implemented the Rivermead motor assessment (RMA) for the first time in Bulgaria.

- Recovery of global function according to Rivermead.

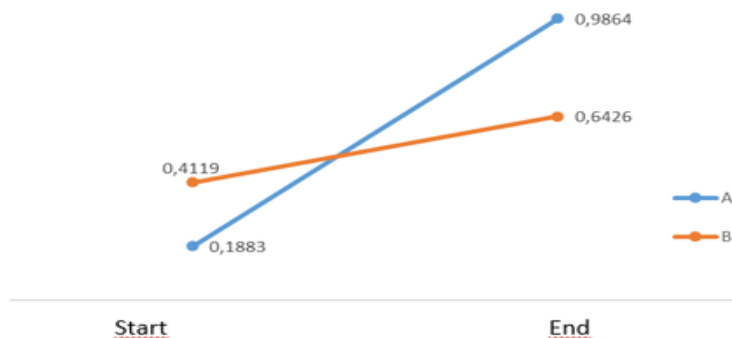
Table 10. Recovery of global function according to Rivermead.

In di ca tor	E N D								
	Result	Group A (n = 81)				Group B (n = 106)			
		NO	YES	X ²	P	NO	YES	X ²	P
S T A R T	1	YES	- 18 22,2%	61,02	***	-	-	-	-
		NO	- 63 77,8%			106 100%	-		
	2	YES	- 8 9,9%	71,01	***	-	39 36,8%	22,04	***
		NO	- 73 90,1%			43 40,6%	24 22,6%		
	3	YES	- 3 3,7%	75,01	***	-	30 28,3%	20,04	***
		NO	1 77 1,3% 95,0%			54 50,9%	22 20,8%		
	4	YES	- 3 3,7%	76,01	***	-	20 18,8%	9,09	***
		NO	- 78 96,3%			75 70,8%	11 10,4%		
	5	YES	- 3 3,7%	76,01	***	-	20 18,8%	8,1	***
		NO	- 78 96,3%			76 71,8%	10 9,4%		
	6	YES	- 3 3,7%	76,01	***	-	28 26,4%	30,03	***
		NO	- 78 96,3%			46 43,4%	32 30,2%		
	7	YES	- -	79,01	***	-	17 16,1%	26,04	***
		NO	- 81 100%			61 57,5%	28 26,4%		
	8	YES	- 2 2,4%	76,01	***	-	17 16,0%	20,04	***
		NO	1 78 1,3% 96,3%			67 63,2%	22 20,8%		
	9	YES	- 1 1,3%	78,01	***	-	15 14,1%	12,07	***
		NO	- 80 98,7%			77 72,6%	14 13,3%		
	10	YES	- 2 2,4%	77,01	***	-	25 23,6%	32,03	***
		NO	- 79 97,6%			47 44,4%	34 32,0%		
	11	YES	- -	54,01	***	-	1 0,9%	5,14	**
		NO	25 30,9% 56 69,1%			98 92,5%	7 6,6%		

12	YES	-	-	0,00	**	-	-	-	-
	NO	80 98,7%	1 1,3%			106 100%	-		
13	YES	-	-	10,08	***	-	-	-	-
	NO	69 85,2%	12 14,8%			106 100%	-		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The results from Table 10. show significant recovery of patients in the experimental group (EG) compared to the control group (CG) at $p < 0.05$. Ninety-five percent of them show improvement in the majority of the indicators. The Knott and Voss methodology proves to be exceptionally effective for the recovery of global function in patients with cerebral stroke.



Graph 9. Mean values or the neck and torso

The results from graph 9. show a significant improvement in patients from group A. The difference in improvement between the two groups is 0.5674. In the conventional kinesitherapy methodology applied in the control group (CG), the recovery of the torso is often neglected, leading to long-term dependence of patients on external assistance.

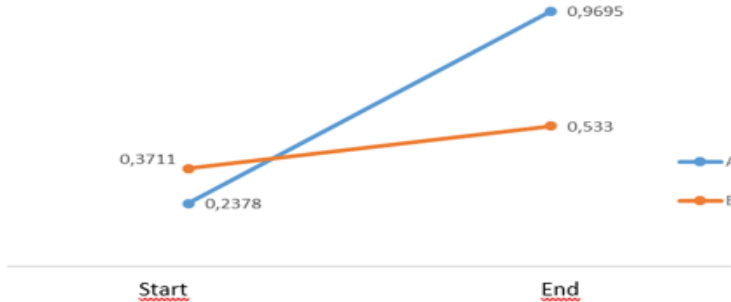
- Of motor function in the lower limb according to Rivermead (RMA)

Table 11. Recovery of motor function in the lower limb according to Rivermead (RMA)

END										
Indicator	Result	Group A (n = 81)				Group B (n = 106)				
		NO	YES	X²	P	NO	YES	X²	p	
S T A R T	1	YES	-	35 43,2%	44,02	***	-	68 64,2%	18,05	***
		NO	-	46 56,8%			18 16,9%	20 18,9%		
	2	YES	-	24 29,7%	54,02	***	-	61 57,6%	10,08	***
		NO	1 1,3%	56 69,0%			33 31,1%	12 11,3%		
	3	YES	-	39 48,2%	40,02	***	-	71 67,0%	23,04	***
		NO	-	42 51,8%			10 9,4%	25 23,6%		
	4	YES	-	3 3,7%	75,01	***	-	32 30,2%	27,03	***
		NO	1 1,3%	77 95,0%			45 42,5%	29 27,3%		
	5	YES	-	38 46,9%	40,02	***	-	60 56,6%	30,03	***
		NO	1 1,3%	42 51,8%			14 13,2%	32 30,2%		
	6	YES	-	10 12,3%	69,01	***	-	24 22,6%	21,04	***
		NO	-	71 87,7%			59 55,7%	23 21,7%		
	7	YES	-	-	72,01	***	-	12 11,3%	6,12	***
		NO	7 8,7%	74 91,3%			86 81,2%	8 7,5%		
	8	YES	-	45 55,6%	34,02	***	-	78 73,6%	13,06	***
		NO	-	36 44,4%			13 12,2%	15 14,2%		
	9	YES	-	17 20,9%	61,02	***	-	43 40,6%	4,16	***
		NO	1 1,3%	63 77,8%			57 53,8%	6 5,6%		
	10	YES	-	4 4,9%	74,01	***	-	19 17,9%	12,07	***
		NO	1 1,3%	76 93,8%			73 68,9%	14 13,2%		

Statistically significant difference *** $p < 0.001$, ** $p < 0.01$

The final assessments from table 11. show improvement in all indicators in both observed groups at $p < 0.001$. The improvement is weak in the control group (CG) and significant in the experimental group (EG). Notably, the improvement in the EG is seen with a large difference in gains in the following test indicators: 7, 9, and 10.



Graph 10. Mean arithmetic values for the lower limb by groups

Graph 10. presents the mean arithmetic values for the lower limb by groups. In group A, the improvement is substantial at 0.7317 points, approaching nearly maximum recovery. Patients in the control group show a slight improvement of 0.162 points. The difference in improvement is 0.569 points in favor of Group A. As a result of the applied methodology of Knott and Voss, spastically increased muscle tone and extensor synergy are suppressed. This leads to smooth transitions between antagonists, stability, mobility of the limb, and optimal function.

- Recovery of Motor function in the hand according to Rivermead

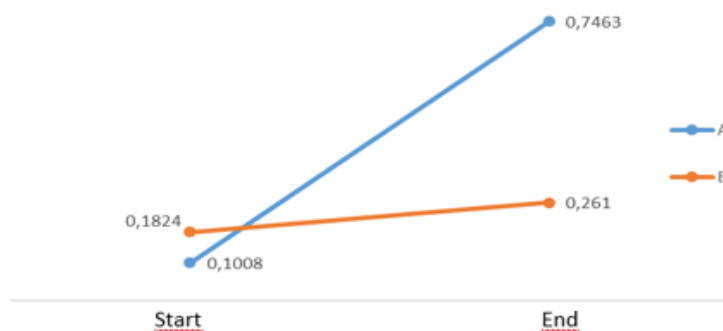
Table 12. Assessment of motor function in the hand according to Rivermead (RMA)

	Indi cator	END								
		Result	Group A (n = 81)				Group B (n = 106)			
			NO	YES	X ²	p	NO	YES	X ²	P
S T A R T	1	YES	-	26 32,0%	52,01	***	-	47 44,4%	6,12	***
		NO	1 1,3%	54 66,7%			51 48,1%	8 7,5%		
	2	YES	-	-	49,02	***	-	9 8,5%	7,11	***
		NO	30 37,1%	51 62,9%			88 83,0%	9 8,5%		
	3	YES	-	-	49,02	***	1 0,9%	11 10,4%	8,1	***
		NO	30 37,1%	51 62,9%			85 80,2%	9 8,5%		
	4	YES	-	28 34,5%	50,02	***	-	61 57,6%	5,14	***
		NO	1 1,3%	52 64,2%			38 35,8%	7 6,6%		
	5	YES	-	25 30,8%	53,02	***	-	47 44,31%	10,08	***
		NO	1 1,3%	55 67,9%			47 44,3%	12 11,4%		
	6	YES	-	9 11,1%	66,01	***	-	26 24,5%	9,09	***
		NO	4 5,0%	68 83,9%			69 65,1%	11 10,4%		
	7	YES	-	3 3,8%	61,02	***	-	12 11,2%	2,25	**
		NO	15 18,5%	63 77,7%			90 85,0%	4 3,7%		
	8	YES	-	-	31,03	***	-	2 1,9%	0,00	**
		NO	48 59,3%	33 40,7%			103 97,2%	1 0,9%		
	9	YES	-	-	69,01	***	-	2 1,9%	14,06	***
		NO	10 12,4%	71 87,6%			88 83,0%	16 15,1%		
	10	YES	-	1 1,3%	67,01	***	-	9 8,5%	8,1	***
		NO	11 13,5%	69 85,2%			87 82,1%	10 9,4%		
	11	YES	-	25 30,8%	53,02	***	-	53 50,0%	7,11	***
		NO	1 1,3%	55 67,9%			44 41,5%	9 8,5%		
	12	YES	-	2 2,5%	67,01	***	-	4 3,8%	39,2	***
		NO	10 12,4%	69 85,1%			87 82,1%	15 14,1%		

	13	YES	-	-	47,02	***	-	6 5,7%	0,5	**
		NO	32 39,5%	49 60,5%			98 92,5%	2 1,8%		
	14	YES	-	-	31,03	***	-	-	00,00	**
		NO	48 59,3%	33 40,7%			105 99,1%	1 0,9%		
	15	YES	-	-	21,04	***	-	-	-	-
		NO	58 71,6%	23 28,4%			106 100%	-		

Statistically significant difference *** $p < 0.001$; ** $p < 0.01$

The final results from table 12. show improvement in both observed groups at $p < 0.001$. The improvement is negligible in the control group (CG), with only a small portion of patients able to perform the corresponding activity, ranging from 0.9% to 15.1%. In contrast, the improvement in the experimental group (EG) is significant and evident across all indicators.



Graph 11. Mean arithmetic values for the hand by groups

Graph 11. presents the mean arithmetic values for hand recovery by groups. The improvement in Group A is substantial at 0.7463 points, while in the control group, it is 0.485 points. The difference in improvement is 0.485 points in favor of Group A. Through the comprehensive methodology, statistically significant improvements in the motor abilities of the hand have been achieved, confirming its effectiveness and benefit in clinical practice.

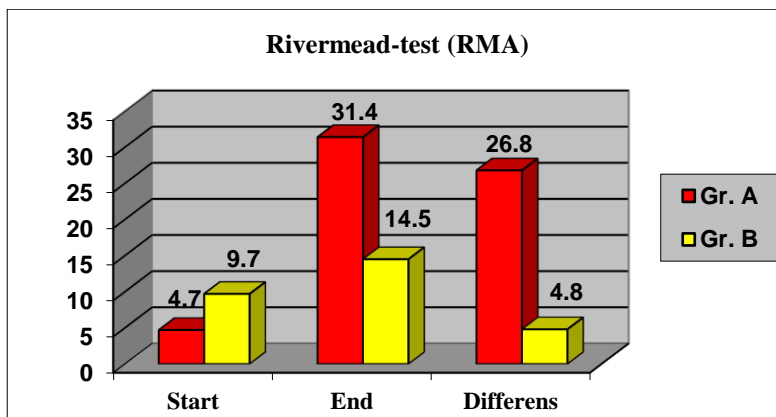


Figure 4. Recovery of motor function according to Rivermead (RMA) - mean values

Figure 4. shows the mean values of the indicators from the Rivermead test at $\alpha = 0.001$ for dependent and independent samples. Improvement is observed in both groups, but it is significant in the experimental group (EG), with an increase of 26.8 points compared to the control group (CG), which shows an improvement of 4.82 points. The difference in improvement is 21.8 points in favor of the EG.

- **Dependence of motor recovery of the limbs on the functionality of the neck and torso**

Table 13. Dependence of motor recovery of the limbs on the functionality of the neck and torso.

Non-parametric correlation of spearman with coefficient "ρ"

EG	Parameter	Neck and torso (start)	Hand (start)	Leg (start)
n= 82	ρ**	1.000	0,737**	0,848**
	P		0.01	0.01
		Neck and torso (end)	Hand (end)	Leg (end)
	ρ**	1.000	0.150	0.126
	P		0.179	0.258
	Parameter	Neck and torso (start)	Hand (start)	Leg (start)
CG	n= 106			
	ρ**	1.000	0,678**	0,848**
	P		0.01	0,01
		Neck and torso (end)	Hand (end)	Leg (end)
	ρ**	1.000	0,781**	0,858**
	P		0,01	0,01

** Correlation is significant at 0.01

In table 13. are processed using non-parametric Spearman correlation with the coefficient " ρ ".

The initial results in patients with more severe motor deficits show a strong dependence in both studied groups between the motor recovery of the hand and leg and the functionality of the torso and neck ($p < 0.01$).

The final results indicate that the strong dependence has been maintained in the control group (CG) ($p < 0.01$). Neglecting and delaying the functional recovery of the torso and neck lead to a lag in the motor recovery of limbs. In the experimental group (EG), there is no statistical dependence ($p > 0.01$). The methodology of Knott and Voss promotes central stability of the torso, providing a foundation for optimal motor recovery of limbs, ultimately achieving a functional level comparable to that of healthy individuals.

Influence of kinesitherapy on the functional recovery of the neck and torso based on the results from the tests: Functional recovery in central motor neuron injury and Rivermead motor assessment (RMA).

The methodology of Knott and Voss demonstrates significant advantages over conventional kinesitherapy in restoring the function of the neck and torso following a cerebral stroke, based on the obtained data from the results. In the experimental group (EG), substantial improvements are observed across all indicators: "Sitting up from a lying position" improves by a difference of 3.30 points, while "Turning to the Side," "Body Rotation," and others improve by 2 to 3 degrees. Emphasizing global movements and coordination aids patients in achieving synergy between the upper and lower halves of the body. This is particularly important for the neck and torso, which serve as the foundation for overall movement.

The low results in the control group (CG) are attributed to passive behavior or even neglect of the work concerning the neck and torso.

- **Kinesitherapy on the functional recovery of the lower limb** based on the results from the tests: Functional recovery in central motor neuron injury and Rivermead motor assessment (RMA).

At the beginning of the treatment, the values of the functional indicators in both groups are similar; however, at the end of the course, Group A demonstrates significant improvement in almost all studied indicators with a high level of significance ($p < 0.001$). The comprehensive methodology is effective in improving the functional condition of the lower limb through specific techniques aimed at normalizing muscle tone, balance, coordination, stability, and mobility.

- **Influence of kinesitherapy on the functional recovery of the upper limb** based on the results obtained from the tests: Functional recovery in central motor neuron injury, Michels test, and Rivermead test.

The data from the results of the tests evaluating the motor function of the upper limb show improvement in both observed groups at $p < 0.001$. The improvement is significantly higher for patients in the experimental group (EG). For the test assessing functional recovery in central motor neuron injury, the improvement is 2.26 points, while in the control group (CG), it is 0.66 points. Particularly effective is the improvement in the EG for the primary movements of the hand across the three tests, such as upward lifting to horizontal, hand-to-mouth, and extension of the wrist and fingers, ensuring good functionality. In this regard, significant contributions come from the effective recovery in the supinated position. The Knott and Voss methodology significantly enhances the stability of the shoulder girdle and torso control, which is foundational for distal motor skills. It promotes brain plasticity and functional recovery, leading to significant improvements in the functionality of the upper limb. These results underscore the importance of early intervention and specific exercises in the rehabilitation of patients with central nervous system injuries.

• **Influence of kinesitherapy on the recovery of locomotion.**

Table 14. Recovery of locomotion.

Locomotor test	Grup A				Grup B			
	Start		End		Start		End	
	Number of patients	Percentages	Number of patients	Percentages	Number of patients	Percentages	Number of patients	Percentages
0	93	65,0	-	-	109	62,3	14	8,0
1	28	19,6	-	-	24	13,7	45	25,7
2	20	14,0	2	1,4	23	13,1	58	33,1
3	2	1,4	65	45,5	17	9,7	50	28,6
4	-	-	78	53,1	2	1,1	8	4,6
Total	143	100	143	100	1175	100	175	100

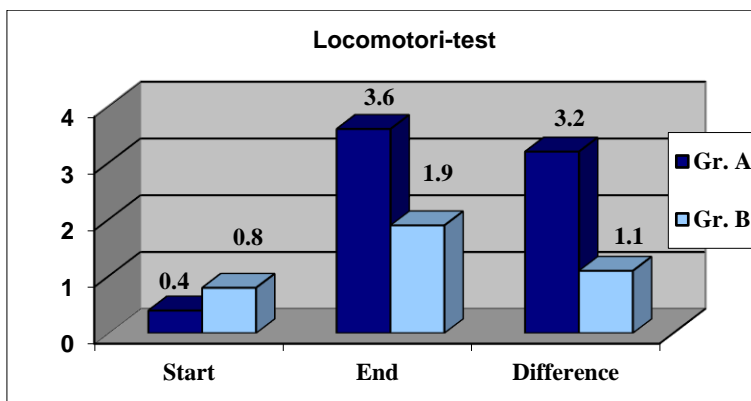


Figure 5. Recovery of locomotion - mean values.

The results from table 14. and figure 5. indicate that at the beginning of the treatment course, the two groups are almost homogeneous—independent walking is impossible, even with assistance. They are at between the zero and first stages. By the end of the treatment course, patients in the experimental group (EG) progress to stages 3 to 4, while those in the control group (CG) are at stages 1 to 2. The difference in gains between the two groups is 2.0 (2 stages) in favor of the EG at $\alpha = 0.001$.

The emphasis of the comprehensive methodology is on achieving central stability and balance in various starting positions,

as well as restoring mobility. A specific and detailed training sequence is applied for proper walking on flat surfaces and stairs.

- **Influence of kinesitherapy on the recovery of self-care and independence**

Table 15. Recovery of Self-Care and independence.

Degree	Group A				Group B			
	Start		End		Start		End	
	Num ber	%	Num ber	%	Num ber	%	Num ber	%
0	81	56,6	0	0	100	57,1	10	5,7
1	38	26,6	1	0,7	25	14,3	45	25,7
2	23	16,1	26	18,2	39	22,3	84	48,0
3	1	0,7	57	39,9	11	6,3	33	18,9
4	0	0	59	41,3	0	0	3	1,7
Num Ber	143	100	143	100	175	100	175	100

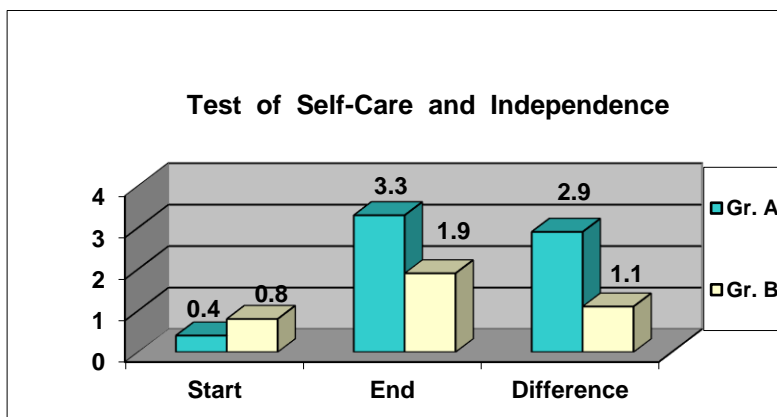


Figure 6. Recovery of Self-Care and independence - mean values.

In table 15. and figure 6., the results of the self-care and independence test are presented. The differences between the beginning and the end in the dependent variables, as well as the differences between the increments in the independent samples, are at a high level of significance $\alpha = 0.001$. The initial results in both groups are similar in value. The largest relative portion is 56.6% from the experimental group (EG) and 57.1% from the control group

(CG) at level 0 – completely dependent on external assistance. Patients from both groups show improvement, which is more significant for the EG, with a difference of $d = 2.9$ (three levels), while in the CG it is 1.0 (one level). The difference (improvement) is 1.8 levels - statistically significant ($p < 0.001$) and favors the EG. Important elements of motor function improved through kinesitherapeutic intervention according to Knott and Voss, which facilitate self-care and independence, include: central stability and balance, coordination between proximal and distal muscles, and systematic training leading to the overcoming of pathological movement patterns.

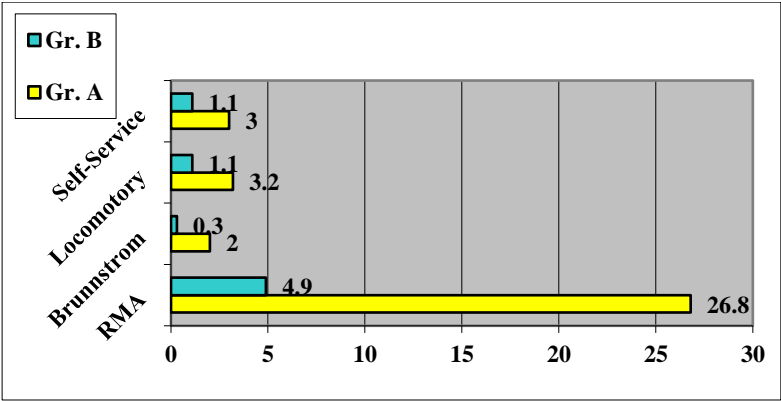


Figure 7. Comparison of functional recovery through the differences - improvement by groups from the conducted tests.

In figure 7., the comparative differences in improvement are presented across four of the applied tests for assessing the motor function of patients who have experienced a stroke. Patients in the experimental group (EG) show significant improvement compared to those in the control group (CG) in the Brunnstrom test with 1.7 stages, in the RMA test with 22 possible indicators, in the locomotor test with 2.1 stages, and in the self-care and independence test with 1.8 stages.

The analysis of the applied tests in patients with stroke reveals

how different aspects of movements related to their recovery interact with each other to form complete motor control.

4. CONCLUSION on confirming or rejecting the working hypothesis:

The study provides compelling evidence in a comparative aspect for the advantages of the kinesitherapy program based on the philosophy and techniques of the comprehensive Knott and Voss methodology, adapted for early clinical application. This approach offers a powerful toolkit and holistic method for achieving significant improvements in motor function following a stroke. It translates the latest achievements in functional imaging related to effectively stimulating neuroplasticity and reorganization of brain activity with appropriate stimuli (including suitable exercises) in patients with central nervous system injuries into clinical practice. The methodology is tailored to the functional needs of patients, optimizing the recovery process and enhancing independence and quality of life.

IN CONCLUSION, the results obtained from the dissertation on the topic: The Potential of the Knott and Voss methodology for functional recovery in acute and subacute stroke stages provide grounds to accept and confirm our working hypothesis.

5. INFERENCES

The comparative results highlight significant advantages of the kinesitherapy program based on the comprehensive Knott and Voss methodology, applied in the acute and subacute stages after a stroke, compared to the standard kinesitherapy program used in healthcare facilities regarding functional recovery, independence, and quality of life for patients.

The kinesitherapy program based on the Knott and Voss methodology effectively contributes to:

1. Targeted motor activation of patients, thus stimulating neural plasticity and enhancing brain reorganization within the spontaneous recovery window (6 weeks to 3 months after stroke).

2. Restoration of overall function, motor function of the neck and torso, the upper and lower limbs; and improving locomotion, independence, and autonomy of patients.

3. Establishing a strong correlation between the recovery of paretic limbs and the functional state of the torso and neck. This underlines the need to focus the kinesitherapy program on the functional recovery of the neck and torso to accelerate limb recovery.

4. Identifying a primary motor deficit in patients with acute and subacute stroke, which impedes independence—the ability to independently transition from supine to sitting. The Knott and Voss kinesitherapy program addresses this issue.

5. Evaluating the importance and potential of combining functional tests for quick general assessment, such as the Brunnstrom test, locomotion, self-care and independence tests, with detailed assessment tests like the CNS injury test, Michels test, and especially the informative Rivermead test for stroke patients to assess motor function and independence.

6. Understanding the significance of the Rivermead test, which evaluates the overall motor function of stroke patients in a sequence from simpler to more complex movements and activities, thus potentially serving as a basis for developing a guideline for sequential and optimal recovery post-stroke.

7. Confirming our observation that the hemispheric location of

the brain lesion can be a prognostic factor for stroke recovery. Patients with right-sided lesions have a poorer prognosis for locomotion recovery.

8. Reinforcing our belief that all stroke survivors should have timely access to the necessary and appropriately tailored kinesitherapy in terms of intensity, duration, and length, in line with various European and global consensus documents.

6. RECOMMENDATIONS:

1. An analysis and selection of an appropriate kinesitherapy approach should be conducted. Our position is that in the acute and subacute stages of stroke, beyond the prevention of complications and passive intervention, active kinesitherapy should be applied alongside spontaneous recovery to achieve autonomy, independence, and a good quality of life.

2. We recommend applying the comprehensive neurophysiological methodology of Knott and Voss at all stages of stroke, particularly in the acute and subacute stages, where it has advantages over other kinesitherapy methods in these stages by unlocking and enhancing movements. This forms the basis for progressing and optimally restoring motor functions.

3. Kinesitherapy programs for stroke should focus on the entire motor continuum, not just isolated limb movements. They should be structured to include tasks that synchronize limb movements with a focus on motor stability of the torso. Exercises targeting activation of the torso and neck muscles should be prioritized in the initial phases of kinesitherapy, as better control of central body parts improves recovery and performance of complex limb movements.

4. Mandatory inclusion of activities in bed, such as turning and achieving independent sit-up from a lying position.

5. Continue research into the interdependence of recovery between the neck, body, and limbs in stroke patients, which will enrich kinesitherapy practice.

6. Early activation (in the first weeks) of the upper limb to achieve optimal function.

7. Implementation of individualized, structured, and adaptable kinesitherapy programs for post-stroke patients.

8. To achieve optimal functional recovery and independence, stroke survivors should have access to kinesitherapy that is necessary in terms of

intensity and duration.

9. The conclusions, recommendations, and contributions of the dissertation should be utilized to develop a national standard for good kinesitherapy practice in stroke patients.

7. CONTRIBUTIONS

Scientific-theoretical contributions:

1. We confirmed the need for intensive kinesitherapy in the acute and subacute stages of stroke for stimulating neuroplasticity and overcoming post-stroke disability.

Scientific-applied contributions:

2. We tested and further developed the comprehensive Knott and Voss methodology, adapting it for clinical application in patients during the acute and subacute stages of stroke.

3. We introduced the Rivermead Assessment (RMA) for the first time in Bulgaria to examine motor function in stroke patients in detail.

4. In connection with SRRR1 recommendations, we found that the hemispheric localization of the brain lesion can be a prognostic factor for recovery in stroke patients. Patients with right-sided lesions are predicted to have more severe recovery outcomes in locomotion.

5. We identified a primary motor deficit in acute and subacute stroke patients, which leads to prolonged inability for independence and self-reliance: the ability to independently transition from lying supine to sitting with legs down. Successful achievement is possible through the complex Knott and Voss methodology.

Practical contributions:

6. We made practical recommendations to improve the effectiveness of kinesitherapy application in stroke patients, meeting the requirements of SRRR.

8. SCIENTIFIC PUBLICATIONS RELATED TO THE DISSERTATION:

1. Manova, N. (2019). Possibilities for upper limb recovery in stroke patients. *Avangard Prima, Physiotherapy*, Vol. XX, No. 1-2/2019, pp. 17-20. ISSN 1314-4642.

2. Manova, N. (2019). Hemispheric localization of stroke as a prognostic factor for functional recovery. *Avangard Prima, Physiotherapy*, Vol. XX, No. 1-2/2019, pp. 21-27. ISSN 1314-4642.

3. Manova, N. (2017). The movement recovery after stroke and the physiotherapy program terms in the reality of the health care reform in Bulgaria. In 1st International Conference on Public Health “From European to National Health Policies”, October 9-10, 2017, Sofia, pp. 392-398.

4. Manova, N. (2023). Our experience in optimizing functional recovery in stroke patients. *Avangard Prima, Physiotherapy*, Vol. XXVIII, No. 1-2/2023, pp. 5-10. ISSN 1314-4642.