Оригінальні дослідження

УДК 616.831-009.11-053.2-085.83-039.76
DOI 10.11603/1811-2471.2018.v0.i4.9732

FORECASTING CAUSED BY KOZYAVKIN© METHOD CHANGES IN HAND FUNCTION PARAMETERS IN CHILDREN WITH SPASTIC FORM OF CEREBRAL PALSY AT THEIR BASELINE LEVELS AS WELL AS EEG, HRV AND GDV

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SUMMARY. Earlier we reported that in children with spastic forms of cerebral palsy (SFCP) after two-week course of rehabilitation by Kozyavkin© method the hand function tests changed ambiguously (in 11 children out of 14 were improved, but in 3 worsened), and these changes were accompanied by a variety changes in a number parameters of EEG, HRV and gas-discharge visualization (GDV).

The aim of this study – to identify the peculiarities of changes in the parameters of EEG, HRV and GDV in children with favorable and unfavorable changes in the parameters of the functions of the hands as well as to find out the possibility of predicting the direction of changes in motor function of the hands on the set of initial parameters of the organism.

Material and Methods. The object of observations were 14 children (6 girls and 8 boys) aged 8–15 years with SFCP. State motor development at GMFCS was on II–IV level. Functional status of the hand with MACS was at II–III level. The estimation of hand function carried out by Dynamometry (D), Box and Block Test (BB) and Nine Hole Peg Test (NHP). We registered also components of muscle tone by device "NeuroFlexor" (Aggero MedTech AB, Sweden), HRV and EEG parameters simultaneosly by hardware-software complex "Cardiolab+VSR" and "NeuroCom Standard" respectively (KhAI Medica, Kharkiv, Ukraine) as well as GDV parameters by "GDV Chamber" ("Biotechprogress", St-Pb, RF).

Results. Using the method of discriminant analysis, 18 parameters were identified, the totality of which the initial state of children and their state after the various consequences of rehabilitation are significantly different from each other. It was found that prognostication by gender, the MACS scale, the BB test of the left hand and the viscous component of muscle tone, despite the uncertainty, is still not sufficiently reliable (the square of Mahalanobis distance D^2_M between the clusters is 6,85; p=0,208). Instead, a discriminant model based on 7 parameters of the EEG and ULF power band of HRV is quite reliable (D^2_M=116; p=0,011). Additional inclusion in the model the parameter of GDV leads to a further increase in the reliability of the forecast (D^2_M=222; p=0,011), which reaches the maximum with the consideration of the BB test of the right hand (D^2_M=262; p=0,002).

Conclusion. The character of the changes in the parameters of the motor function of the hands due to the course of rehabilitation by Kozyavkin© method is conditioned both by their initial level and by the set of parameters of EEG, HRV and GDV and is subject to reliable prediction.

KEY WORDS: Cerebral palsy; Dynamometry; Box and Block Test; Nine Hole Peg Test; Neural; Elastic and Viscous components of Muscle Tone; EEG; HRV; GDV; Intensive Neurophysiological Rehabilitation System by Kozyavkin© method.

Introduction. Earlier we reported that after two-week course of Intensive Neurophysiological Rehabilitation System (INRS), officially recognized as Kozyavkin© method [1–3], the parameters of the functional tests of hands in 108 children with spastic forms of cerebral palsy (SFCP) are significantly improved. In total the effectiveness of the restoration of functional parameters of hands by Kozyavkin© method makes average (23,3±1,6) % versus (3,5±1,4) % in control. However, the average values obscure significant differences between individual children. In particular, in 58 % of patients, changes are very tangible, in 22 % moderate, while in 20 % are minor [4]. In another contingent of 29 children, we found that reducing neural component of muscle tone (NCMT) stated in 79.3% cases from (7,6±1,0) N to (1.6±0.5) N (direct difference: (-6,0±0,8) N), while in 13,8 % cases changes were not detected and in 2 children only NCMT increased from 1.6 to 3.4 and from 4.6 to 6.1 N respectively [5,6]. We have recently been shown that changes in manual functional tests and NCMT are determined by variety in parameters of EEG and HRV as well as GDV [7, 8].

In the last article [9] in a sample of 14 children, we stated that in 11 children rehabilitation led to favorable changes in the parameters of the function of the hands, while in 3 children they turned out to be unfavorable. The method of discriminant analysis revealed that unfavorable changes are accompanied by a decrease in the asymmetry of the θ- and δ-rhythms, the spectral power density (SPD) of β-rhythm in loci F8 and Fp1, instead, it increases in loci O1 and T3, leading to left-sided lateralization of the β-rhythm. At the same time, the SPD of the α-rhythm in locus O1 and the θ-rhythm in locus F4 rises as well as its Deviation. These changes in the EEG are accompanied by a reduction in vagalis and an increase in sympathetic tones. Among the GDVs parameters, an increase in the area of the GD Image in the frontal projection, coupled with a decrease in its Entropy in the frontal and left projections, was found. Instead, favorable changes in the parameters of the hand function are accompanied by opposite changes in the listed EEGs, HRVs and GDVs parameters or their absence.

In this study, we set the goal, firstly, to identify the peculiarities of changes in the parameters of EEG, HRV and GDV in children with favorable and unfavorable changes in the parameters of the functions of the hands, and secondly, to find out the possibility of predicting the effect of rehabilitation by Kozyavkin© method on a set of initial parameters of the body.

Material and Research Methods. The object of observations were 14 children (6 girls and 8 boys) aged 8÷15 years with Spastic Forms of Cerebral Palsy. Diagnose, Stage, Phase as well as Gross Motor Function Classification System [10] and Manual Ability Classification System [11] levels is given in the Table 1.

Table 1. Clinical characteristics of the observed children

Child	Gender	Age	Diagnose	Stage	Phase	GMFCS	MACS
Hou L	Girl	14	**G80.0 CCP: spastic tetraplegia**	movement by turning	lying to the control head	4	3
Myk	Boy	10	**G80.1 CCP: spastic diplegia**	crawling on their bellies	independent seat	4	3
Pet	Girl	10	**G80.1 CCP: spastic diplegia**	walking on the knees	getting up at the support	4	3
Hou D	Girl	14	**G80.1 CCP: spastic diplegia**	walk with aids	independent seat	3	3
Hav	Boy	10	**G80.1 CCP: spastic diplegia**	walk with aids	rising support near	3	3
Pav	Boy	9	**G80.1 CCP: spastic diplegia**	walk with aids	rising support near	3	2
Boj A	Boy	15	**G80.1 CCP: spastic diplegia**	walk with aids	self-rising	2	2
Boj D	Boy	15	**G80.1 CCP: spastic diplegia**	independent moves	self-rising	2	2
Vor	Boy	9	**G80.1 CCP: spastic diplegia**	independent moves	self-rising	2	2
Kry	Boy	8	**G80.2 CCP: spastic hemiplegia Left**	independent moves	self-rising	2	2
Lan	Girl	12	**G80.2 CCP: spastic hemiplegia Left**	independent moves	rising support near	2	2
Kul	Girl	12	**G80.1 CCP: spastic diplegia**	alternative crawling	independent seat	4	3
Kuch	Girl	13	**G80.1 CCP: spastic diplegia**	walk with aids	rising support near	3	3
Str	Boy	12	**G80.2 CCP: spastic hemiplegia Left**	independent moves	self-rising	1	1

The estimation of hand function carried out by Dynamometry (D), Box and Block (BB) test and Nine Hole Peg (NHP) test. To measure the strength of the hand we used dynamometer of "Jamar" company [12]. The essence of the BB test by V Mathiowetz et al [13] is to determine the number of wooden cubes that patient can shift from one box to the second in a minute. The essence of NHP test [14,15] is to determine how long the patient can turn each hand insert and then remove wooden 9 pegs in 9 holes in the wooden bar.

For each test we calculated Laterality Index (LI) using the equation:

LI=100 %•(Right – Left)/0,5•(Right + Left)

We registered also Neural, Elastic and Viscous components of Muscular Tone by device "NeuroFlexor" (Aggero MedTech AB, Sweden). Recent studies have indicated that device is suitable for measurement changes in spasticity during CP treatment [6, 16–19].

The next morning in a sitting position we recorded during 7 min electrocardiogram in II lead by hardware-software complex "CardioLab+HRV" ("KhAI-Medica", Kharkiv, Ukraine) to assess the parameters of HRV as markers of vagal and sympathetic outflows. For further analysis the following parameters HRV were selected. Temporal parameters (Time Domain Methods): the standart deviation of all NN intervals (SDNN), coefficient of variation (C_V), the square root of the mean of the sum of the squares of differences between adjacent NN intervals (RMSSD), the percent of interval differences of successive NN intervals greater then 50 ms (pNN_{50}), triangulary index (TINN);

heart rate (HR). Spectral parameters (Frequency Domain Methods): spectral power (SP) bands of HRV: high-frequency (HF, range 0,4÷0,15 Hz), low-frequency (LF, range 0,15÷0,04 Hz), very low-frequency (VLF, range 0,04÷0,015 Hz) and ultra low-frequency (ULF, range 0,015÷0,003 Hz). We calculated also relative SP all bands as well as classical indexes: LF/HF and LFnu=100%•LF/(LF+HF) [20–22].

Simultaneosly with HRV we recorded EEG for 25 sec using hardware-software complex "NeuroCom Standard" (KhAI Medica, Kharkiv, Ukraine) monopolar in 16 loci (Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, P3, P4, T5, T6, O1, O2) by 10-20 international system, with the reference electrodes A and Ref on the ears tassels. Among the parameters considered the average EEG amplitude (μV), average frequency (Hz), frequency deviation (Hz), index (%), coefficient of asymmetry (%) as well as absolute (μV^2/Hz) and relative (%) spectral power density (SPD) in the standard frequency bands: β (35÷13 Hz), α (13÷8 Hz), θ (8÷4 Hz) and δ (4÷0,5 Hz) in all loci, according to the instructions for the device. In addition, we calculated Laterality Index (LI) for SPD each Rhythm using formula:

LI, % = Σ [200•(Right – Left)/(Right + Left)]/8

We calculated also for each locus the Entropy (h) of normalized SPD using classical CE Shannon's formula:

$$h=-[SPD\alpha \bullet \log_2 SPD\alpha + SPD\beta \bullet \log_2 SPD\beta + SPD\theta \bullet \log_2 SPD\theta + SPD\delta \bullet \log_2 SPD\delta]/\log_2 4$$

In 1996 KG Korotkov created a new scientific approach, based on the digital videotechnics, modern electronics and computer processing quantitative data, called as method gas discharge visualization (GDV bioelectrography). Parallel uses the terms Kirlianography and Electrophotonics. Method of GDV, essence of which consists in registration of photoelectronic emission of skin, induced by high-frequency electromagnetic impulses, allows to estimate integrated psycho-somatic state of organism. It is considered that parameters of GDV, taken off without filter, characterizes the current psychophysiological condition of organism while registered with a filter characterizes vegetative regulation at the level of stable physiological processes [23]. Since ambiguous attitude to the method (between excellent and fickle), previously we conducted the study on its verification and have shown that GDV parameters are correlated with HRV and EEG parameters as well as can change with variation in other functional parameters of the body [24, 25].

The Kirlianogram have been registered by the method of GDV with the use the device "GDV Chamber" ("Biotechprogress", SPb, RF) [23].

After testing children within two weekes received a classic course rehabilitation (a detailed description is provided in the manual [3]), then repeated the tests listed.

Digital material is treated by method discriminant analyses [26] with the use of package of softwares "Statistica-5.5".

Results and Discussion. In the previous article [9], treated children were divided into two clusters: major (11 members) with favorable changes in functional hand tests and minor (3 members) with adverse changes. Proceeding from this, at the next stage, using the method of discriminant analysis (forward stepwise), parameters were identified, the totality of which the initial state of children and their state after the various consequences of rehabilitation are significantly different from each other. The program selected 18 parameters, namely 3 **hand function** parameters, 10 **EEGs**, 2 **HRVs** and 3 **GDVs**. The hierarchy of parameters for their differentiation ability, estimated by criterion Λ, is given in Table 2.

Table 2. Summary of Stepwise Analysis. The scale of ranks for variables

Variables currently in the model	F to enter	p-level	Λ	F-value	p-level
1	2	3	4	5	6
LF HRV, sec2	5,9	,008	,681	5,9	,008
LFnu HRV, %	5,6	,010	,464	5,6	10^{-3}
δ-rhythm Deviation. Hz	3,1	,066	,366	5,0	10^{-3}
β-rhythm Amplitude, μV	3,5	,047	,277	5,0	10^{-3}
F8-β SPD, μV2/Hz	2,1	,148	,231	4,5	10^{-3}
Entropy Right GDV	2,4	,119	,186	4,4	10^{-3}
θ-rhythm Deviation, Hz	2,0	,168	,155	4,2	10^{-3}
O1-θ SPD, μV2/Hz	1,9	,184	,128	4,0	10^{-3}
O2-θ SPD, %	2,3	,129	,101	4,1	10^{-3}
β-rhythm Laterality, %	2,2	,143	,079	4,1	10^{-3}
Area Frontal GDV, 103 pixels	3,0	,082	,057	4,4	10^{-3}
F4-β SPD, μV2/Hz	3,6	,056	,037	4,9	10^{-4}
F3-β SPD, %	1,8	,204	,029	4,8	10^{-4}
Fp1-β SPD, μV2/Hz	3,1	,084	,019	5,3	10^{-4}

Table 2

1	2	3	4	5	6
Entropy Frontal (f) GDV	1,7	,221	,015	5,3	10^{-4}
Dynamometry Right, kG	6,8	,014	,006	7,3	10^{-4}
9 Hole Peg Left, sec	2,3	,157	,004	7,7	10^{-4}
Dynamometry Laterality, %	1,6	,253	,003	7,8	10^{-4}

Next, the 18-dimensional space of discriminant variables transforms into 2-dimensional space of a canonical discriminant roots, which is a linear combination of discriminant variables. The discriminating (differentiating) ability of the root characterizes the canonical correlation coefficient (r*) as a measure of connection, the degree of dependence between groups and a discriminant function. The first root contains 81 % discriminant capacity, while the second root 19 % only.

Table 3 presents raw (actual) and standardized (normalized) coefficients for discriminant variables. The raw coefficient gives information on the absolute contribution of this variable to the value of the discriminative function, whereas standardized coefficients represent the relative contribution of a variable independent of the unit of measurement. They make it possible to identify those variables that make the largest contribution to the discriminatory function value.

Table 3. Standardized, Structural and Raw Coefficients and Constants for Canonical Variables

Variables currently in the model	**Standardized**		**Structural**		**Raw**	
	Root 1	Root 2	Root 1	Root 2	Root 1	Root 2
β-rhythm Laterality, %	-3,628	,062	**-,069**	-,052	-,1449	,0025
F4-β SPD, μV2/Hz	-2,238	,094	**-,060**	-,049	-,0304	,0013
β-rhythm Amplitude, μV	4,151	1,839	**-,039**	,015	,8056	,3569
O1-θ SPD, μV2/Hz	-5,090	-,533	**-,028**	-,013	-,0294	-,0031
Dynamometry Right, kG	3,595	,154	**,041**	,012	,4837	,0207
O2-θ SPD, %	5,150	,261	**,025**	-,018	,8834	,0447
LF HRV, sec2	-2,123	,053	-,002	**,236**	-,0029	,0001
Area Frontal GDV, 103 pixels	4,189	1,177	,005	**,126**	1,7	0,5
Dynamometry Laterality, %	-1,414	1,757	,019	**,125**	-,0658	,0817
δ-rhythm Deviation. Hz	-1,239	1,205	,007	**,123**	-3,5178	3,4198
θ-rhythm Deviation, Hz	3,605	1,665	,019	**,120**	5,2427	2,4220
F3-β SPD, %	-4,591	-1,112	-,017	**,113**	-,2940	-,0712
LFnu HRV, %	-3,060	-,444	-,047	**,091**	-,2132	-,0309
9 Hole Peg Left, sec	-,702	-1,333	-,003	**,045**	-,0100	-,0190
Entropy Right GDV	-,686	-1,398	,044	**-,135**	-5,0259	-10,243
Fp1-β SPD, μV2/Hz	-1,491	,004	-,007	**-,108**	-,0245	,0001
F8-β SPD, μV2/Hz	3,634	-,091	,031	**-,099**	,0514	-,0013
Entropy Frontal (f) GDV	-5,125	-3,298	,002	**-,084**	-27,67	-17,80
Eigenvalues	**35,13**	**8,42**	**Constants**		75,95	89,90
	Discriminant Properties, %				**81**	**19**
	r^*_1=0,986; Wilk's Λ=0,003; $x^2_{(36)}$=96; p<10^{-6} r^*_2=0,945; Wilk's Λ=0,106; $x^2_{(17)}$=37; p=0,003					

The same is the full structural coefficients, that is, the coefficients of correlation between the discriminant root and variables. The structural coefficient shows how closely variable and discriminant functions are related, that is, what is the portio of information about the discriminant function (root) contained in this variable.

As you can see, the first root **inversely** reflects the information on 4 **EEGs parameters** while **directly** on O1-θ SPD and Dynamometry of Right hand. The second root represents directly 2 **HRVs**, 3 **EEGs**, 2 **functional hand** parameters as well as one parameter of **GDV**, while inversely reflects others 2 **GDVs** and 2 **EEGs** parameters.

The sum of products of raw coefficients on the value of discriminant variables together with the constant gives the values of roots for each child and allow their visualization (Figs. 1–5) as well as clusters of children (Fig. 6).

Even at first glance it is possible to state a drastically difference between clusters. The visual impression is documented by calculating the square of Mahalanobis distance (D^2_M). Between initial cluster and cluster with favorable consequences D^2_M=143 (F=14,4; p<10^{-3}), with unfavorable changes: 209 (F=6,4; p=0,006), while between two post-rehabilitated clusters: 100 (F=3,0; p=0,06).

Localization of representative children's points along the axis of the first root (Figs. 1 and 2) reflects, firstly, significant changes under the influence of rehabilitation in six parameters associated with the roots (Table. 4), in particular, alignment of the right lateralization of β-rhythm, reduction of its amplitude and SPD in locus F4 as well as SPD of θ-rhythm in locus O1 while increase it in locus O2 as well as increase strength of the right hand and right-site lateralization of dynamometry. At the same time, intercluster differences for these parameters are insignificant, which is documented as the average values of centroid clusters (Fig. 6) and their displacements (+11,0±0,6) and (+12,0±0,2) with favorable and unfavorable changes of functions of hands, respectively, see Fig. 4).

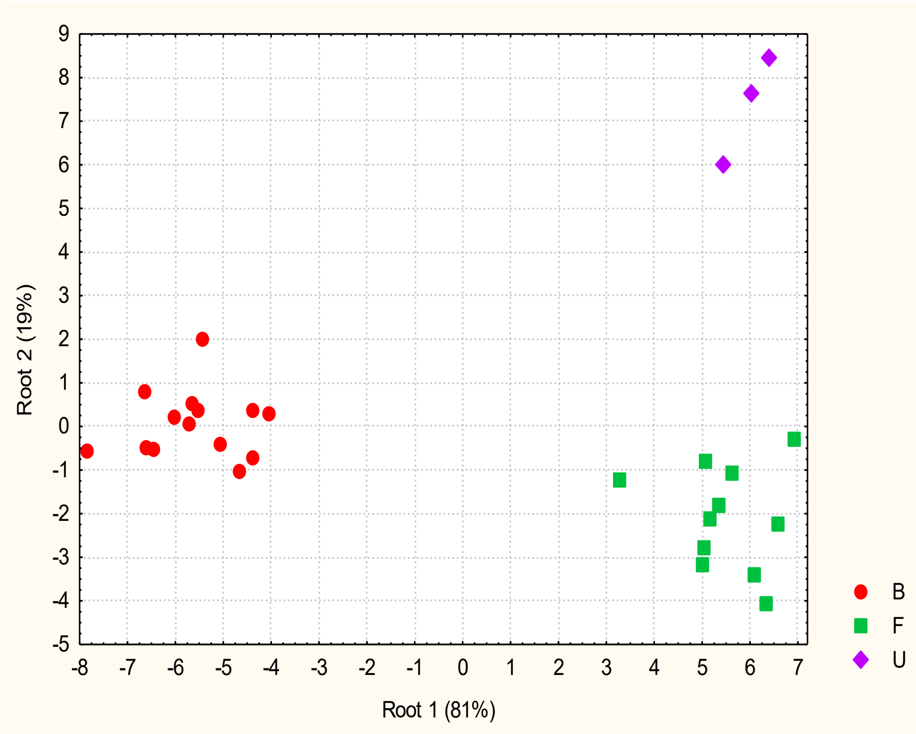

Fig. 1. Individual sizes of canonical discriminatory roots of children before rehabilitation (**Baseline**) and with its **favorable** (F) and **unfavorable** U) consequences.

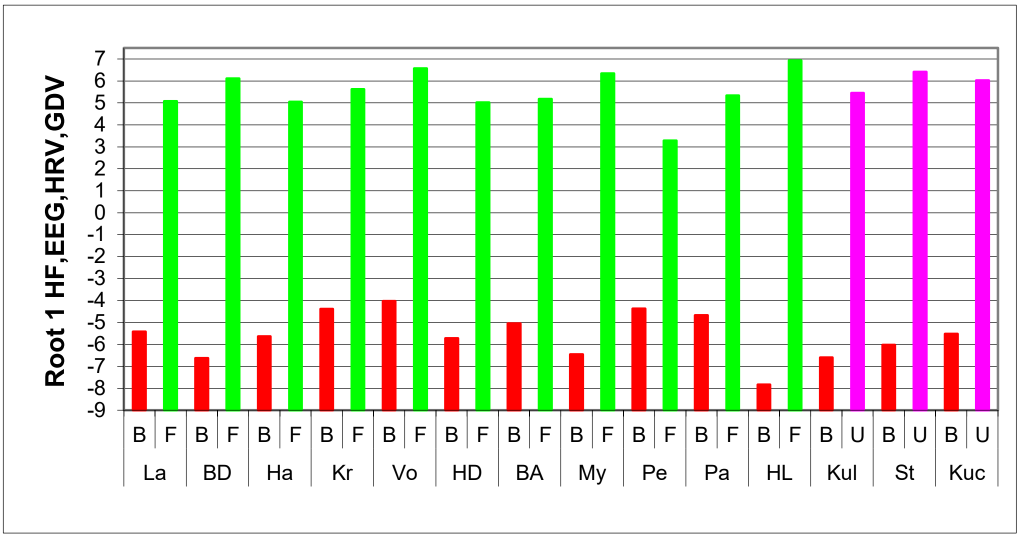

Fig. 2. Individual sizes of first root of children **before** rehabilitation and with its **favorable** (F) and **unfavorable** (U) consequences.

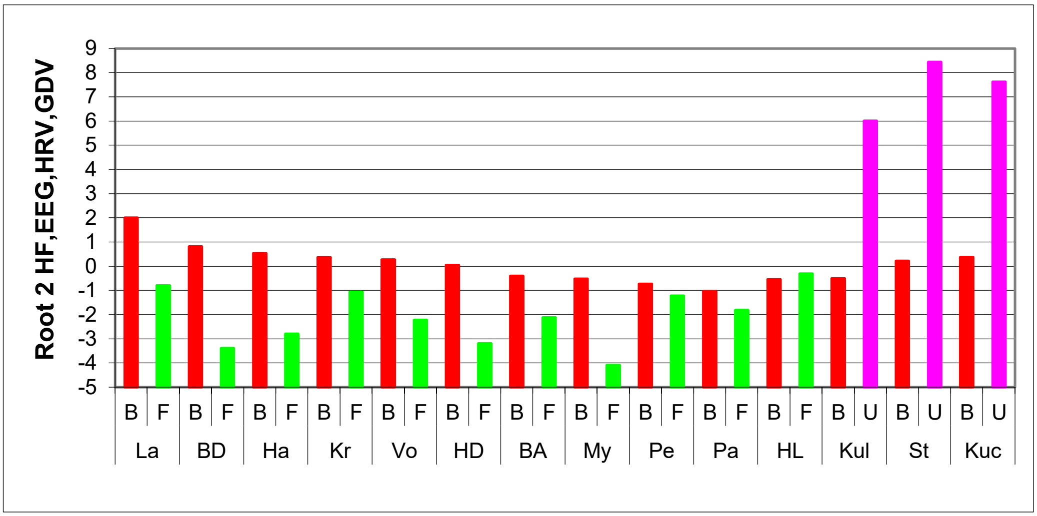

Fig. 3. Individual sizes of second root of children **before** rehabilitation and with its **favorable** (F) and **unfavorable** (U) consequences.

Fig. 4. Individual changes in first root of children with **favorable** (F) and **unfavorable** (U) consequences of rehabilitation.

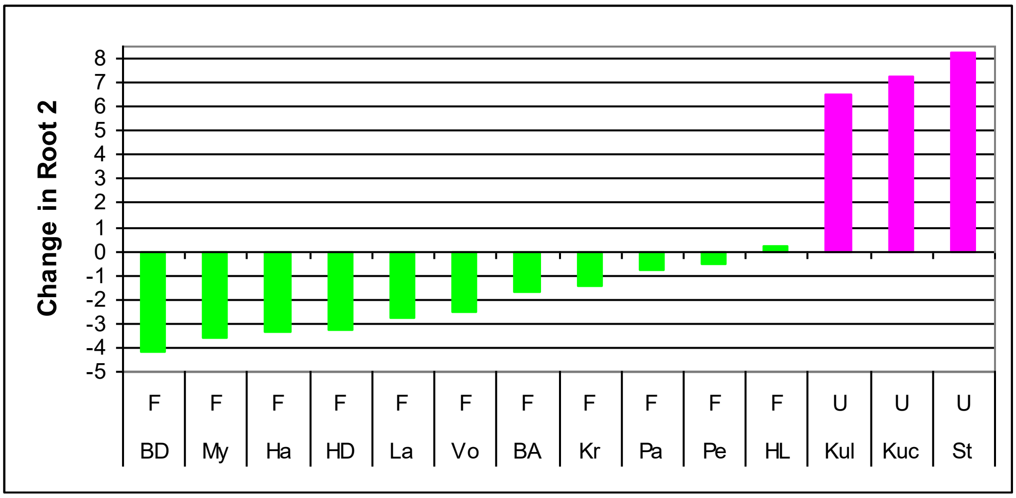

Fig. 5. Individual changes in second root of children with **favorable** (F) and **unfavorable** (U) consequences of rehabilitation.

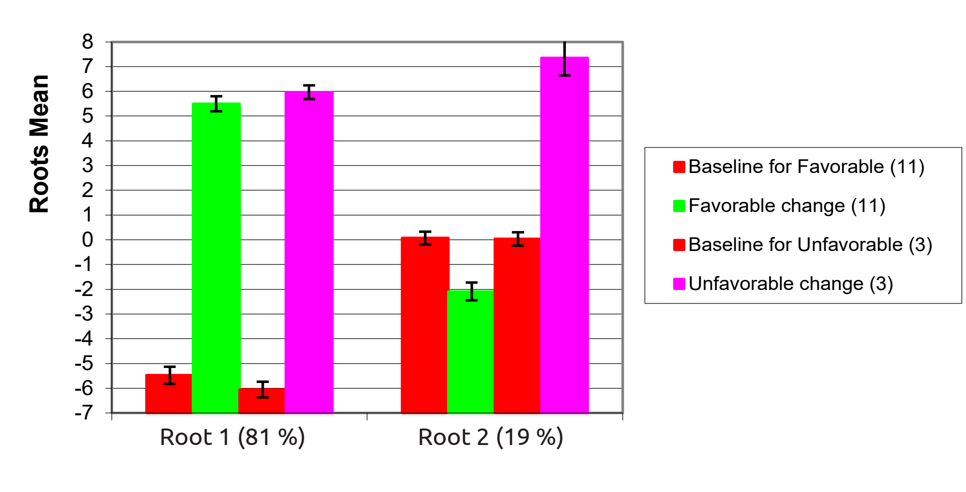

Fig. 6. Means of canonical discriminatory roots of children before rehabilitation (**Baseline**) and with its **favorable** (F) and **unfavorable** (U) consequences.

Table 4. Discriminant Function Analysis Summary. Variables currently in the model

Step 18, N of vars in model: 18; Grouping: 3 grps

Wilks' Lambda: 0,0029; approx. $F_{(36)}=7,8$; $p<10^{-6}$

Variables	Basal level	Changes in Hand Function		Wilks' Λ	Partial Λ	F-remove (2,9)	p-level	Tole-rancy
		Favorable (n=11)	Unfavorable (n=3)					
β-rhythm Laterality, %	+18±7	+1±7	-12±12	,0154	,191	16,89	,001	,063
F4-β SPD, μV²/Hz	175±25	132±16	95±17	,0075	,393	6,17	,024	,124
β-rhythm Amplitude, μV	17,9±1,6	15,4±1,3	16,0±2,1	,0066	,447	4,96	,040	,028
O1-θ SPD, μV²/Hz	157±63	106±27	83±24	,0278	,106	33,77	10^{-4}	,035
O2-θ SPD, %	10,4±1,7	12,3±1,6	11,4±3,0	,0202	,146	23,46	10^{-3}	,033
Dynamometry Right, kG	20,1±1,9	23,4±2,5	24,3±0,3	,0052	,562	3,12	,100	,035
Dynamometry Laterality, %	+9,5±6	+8±6	+34±7	,0041	,709	1,64	,253	,062
Area Frontal GDV, 10³ pixels	27,6±0,5	27,1±0,9	30,1±1,3	,0202	,145	23,55	10^{-3}	,047
Entropy Frontal (f) GDV	3,91±0,04	3,95±0,06	3,80±0,12	,0132	,223	13,97	,003	,022
Entropy Right GDV	3,86±0,04	3,96±0,04	3,79±0,02	,0044	,674	1,94	,206	,148
δ-rhythm Deviation. Hz	0,65±0,11	0,59±0,06	1,00±0,29	,0072	,411	5,73	,028	,211
θ-rhythm Deviation, Hz	1,08±0,13	1,05±0,27	1,83±0,44	,0240	,123	28,60	10^{-3}	,058
F3-β SPD, %	27±4	20±5	36±13	,0136	,216	14,51	,002	,036
F8-β SPD, μV²/Hz	120±19	160±21	95±54	,0145	,203	15,69	,002	,062
Fp1-β SPD, μV²/Hz	109±14	119±23	56±4	,0055	,532	3,51	,080	,216
LF HRV, sec²	974±122	592±36	2202±1177	,0072	,409	5,77	,028	,135
LFnu HRV, %	74,3±3,2	64,0±5,1	76,1±7,9	,0072	,406	5,84	,027	,064
9 Hole Peg Left, sec	110±19	101±22	131±8	,0042	,704	1,68	,245	,143

The clear separation of clusters occurs along the axis of the second root, herewith the centroids of the post-rehabilitation clusters shift relative to the initial in opposite directions (Figs. 1, 3 and 5). In particular, unfavorable changes in the functions of the hands are accompanied by an: 1) extension of the GDV area in the frontal projection, coupled with a decrease in its entropy in the same place and in the right projection; 2) increase in volatility of δ- and θ-rhythms as well as in SPD of β-rhythm in locus F3 while decrease its in loci F8 and Fp1; 3) increase in power of LF band of HRV as marker of sympathetic tone. On the other hand, favorable functional changes are accompanied by opposite changes in GDVs, EEGs and HRVs parameters or no changes in relation to the initial levels.

Despite the fact that the program did not include most of the parameters of the functions of the hands in a discriminant model, as well as a number of GDVs, EEGs and HRVs parameters, we consider it necessary to bring them in a separate table 5, as they are quite worthy of attention.

Table 5. Discriminant Function Analysis Summary. Variables currently not in the model

Variables	Basal level	Changes in Hand Function		Wilks' Λ	Partial Λ	F to enter (2,7)	p-level	Tole-rancy
		Favorable (11)	Unfavorable (3)					
Area Left GDV, 10^3 pixels	26,7±0,4	25,7±0,5	30,0±2,2	,0013	,857	,58	,584	,168
Shape Coefficient Left GDV	13,2±0,6	14,1±1,1	12,8±1,9	,0013	,840	,67	,544	,218
Shape Coeff. Frontal (f) GDV	13,2±0,5	13,9±0,8	12,8±0,1	,0014	,887	,45	,657	,168
T3-β SPD, %	29±5	21±4	46±18	,0013	,885	,45	,653	,036
O1-α SPD, μV²/Hz	232±86	223±74	309±168	,0014	,917	,32	,738	,137
Entropy SPD in F4 EEG	0,85±0,04	0,76±0,06	0,86±0,05	,0015	,987	,04	,957	,477
F4-θ SPD, %	13,4±2,0	12,2±2,4	13,4±1,0	,0015	,963	,14	,875	,266
C3-δ SPD, μV²/Hz	301±117	542±276	170±106	,0015	,954	,17	,849	,323
P3-δ SPD, μV²/Hz	332±114	914±497	225±223	,0013	,871	,52	,616	,363
T4-α SPD, μV²/Hz	154±34	150±36	91±47	,0012	,811	,82	,480	,040
θ-rhythm Amplitude, μV	14,4±2,2	14,2±1,9	10,2±2,2	,0014	,920	,30	,748	,072
HF HRV, %	14,7±2,1	21,0±4,5	12,4±3,6	,0014	,932	,25	,782	,070
Box&Block Right, block/min	18,8±2,0	18,4±2,4	13,7±1,1	,0014	,932	,26	,781	,122
Box&Block Left, blocks/min	14,8±1,4	16,7±1,7	13,8±0,7	,0013	,862	,56	,594	,143
Dynamometry Left, kG	17,7±1,0	20,7±1,2	17,4±1,4	,0014	,949	,19	,834	,010
9 Hole Peg Right, sec	116±18	105±20	132±2	,0015	,972	,10	,906	,095
9 Hole Peg Laterality, %	+6±9	+7±11	+1±5	,0014	,909	,35	,716	,304
Box&Bloks Laterality, %	+2±3	+7±6	-1±4	,0013	,837	,68	,536	,339
C3-α SPD, %	32±2	27±5	30±3	,0015	,954	,17	,849	,265
Neural CMT, Neutons	16,0±2,7	11,8±2,5	13,8±3,3	,0015	,987	,14	,875	,266

It can be seen that the deterioration of the functional tests of both hands, in particular the decrease of the number of transferred blocks per minute and the extension of the time of insertion of the pegs into the holes, in the absence of changes in the strength of the left hand and the neural component of muscle tone, is accompanied by: 1) an increase in the area of GD Image in the left projection in combined with a decrease in the coefficient of its form (vertex of the contour of the image) in both the left and the frontal projections; 2) decrease in power of HF band of HRV as marker of parasympathetic tone as well as amplitude of θ-rhythm, SPD of α-rhythm in locus T4 and δ-rhythm in loci P3 and C3 while increase in SPD of α-rhythm in locus O1 and β-rhythm in locus T3 in the absence of changes in SPD of α-rhythm in locus C3 and θ-rhythm in locus F4 as well as Entropy of SPD in this locus. On the other hand, reduction of spasticity of the left hand, increase of its strength and improvement of abilities is accompanied by opposite changes of the mentioned parameters GDV, HRV and EEG, as well as reduction of SPD of α-rhythm in locus C3 and θ-rhythm in locus F4 as well as Entropy of SPD in this locus.

The same discriminant parameters can be used to identify (classify) the belonging of one or another child to original as well as unfavorable or favorable group. This purpose of discriminant analysis is realized with the help of classifying (discriminant) functions (Table 6).

Table 6. Coefficients and Constants for Classification Functions

Variables currently in the model	Baseline	Favorable	Unfavorable
	p=,500	p=,393	p=,107
1	2	3	4
LF HRV, sec²	,362	,330	,329
LFnu HRV, %	25,42	23,12	22,73
δ-rhythm Deviation. Hz	37,89	-8,520	22,16
β-rhythm Amplitude, μV	-136,9	-128,7	-125,0
F8-β SPD, μV²/Hz	-3,153	-2,580	-2,568
Entropy Right GDV	2568	2535	2436
θ-rhythm Deviation, Hz	-697,7	-644,8	-619,5
O1-θ SPD, μV²/Hz	2,814	2,494	2,452
O2-θ SPD, %	-88,95	-79,24	-78,41

Table 6

1	2	3	4
β-rhythm Laterality, %	12,97	11,35	11,31
Area Frontal GDV, 10^3 pixels	-181	-163	-158
F4-β SPD, μV^2/Hz	2,487	2,147	2,145
F3-β SPD, %	39,41	36,30	35,49
Fp1-β SPD, μV^2/Hz	1,582	1,310	1,299
Entropy Frontal (f) GDV	5054	4785	4605
Dynamometry Right, kG	-64,81	-59,49	-59,07
9 Hole Peg Left, sec	2,324	2,254	2,071
Dynamometry Laterality, %	1,555	,649	1,390
Constants	-11867	-11220	-10364

These functions are special linear combinations that maximize differences between groups and minimize dispersion within groups. The coefficients of the classifying functions are not standardized, therefore they are not interpreted. An object belongs to a group with the maximum value of a function calculated by summing the products of the values of the variables by the coefficients of the classifying functions plus the constant. In this case, we can retrospectively recognize members of all groups unmistakably. Now let's move on to the realization of the main goal of the study, namely the retrospective prediction of the effect of rehabilitation of motor function of the hands. The same method of discriminant analysis is applied. At the first stage, only demographic and functional parameters were taken as predictors. The program included four initial parameters in the prognostic model (Table 7–9).

Table 7. Discriminant Function Analysis Summary for parameters of Hand function

Step 4, N of vars in model: 4; Grouping: 2 grps
Wilks' Lambda: ,5040; approx. $F_{(4,9)}$=2,2; p=0,148

Variables currently in the model	**Unfavorable changes (3)**	**Favorable changes (11)**	**Wilks' Λ**	**Partial Λ**	**F-remove (1,9)**	**p-level**	**Tolerancy**
Viscous CMT, N	0,13±0,05	-0,26±0,11	,594	,848	1,6	,236	,710
B&B Left, blocks/min	18,7±0,8	13,8±1,6	,569	,886	1,2	,310	,626
Sex Index (B=0; G=1)	0,67±0,33	0,36±0,15	,749	,673	4,4	,066	,452
MACS, points	2,33±0,67	2,45±0,16	,580	,869	1,4	,274	,593
Variables currently not in the model			**Wilks' Λ**	**Partial Λ**	**F to enter (1,8)**	**p-level**	**Tolerancy**
GMFCS, points	2,67±0,88	2,82±0,26	,503	,998	,02	,901	,199
Age, years	12,3±0,3	11,4±0,8	,499	,990	,08	,779	,743
B&B Right, blocks/min	18,8±2,0	14,3±1,8	,482	,956	,37	,560	,113
D Right, kG	21,2±3,5	19,8±2,3	,503	,998	,02	,902	,624
D Left, kG	17,8±1,5	17,7±1,2	,481	,954	,39	,551	,498
D Laterality, %	+15±11	+8±8	,503	,998	,01	,911	,772
Neural CMT, N	12,1±3,3	17,1±3,3	,483	,959	,34	,575	,674
Elastic CMT, N	3,1±0,8	3,5±0,8	,502	,997	,03	,874	,298
NHP Right, sec	72±23	129±22	,487	,967	,28	,614	,217
NHP Left, sec	64±14	122±23	,480	,952	,41	,541	,073
B&B Laterality, %	-1±7	+2±3	,467	,927	,63	,449	,895
NHP Laterality, %	+1±25	+8±10	,493	,979	,17	,688	,476

Table 8. Summary of Stepwise Analysis for parameters of Hand function

Variables currently in the model	F to enter	p-level	Λ	F-va-lue	p-level
Viscous CMT, N	3,52	,085	,773	3,5	,085
Sex Index (B=0; G=1)	1,98	,187	,655	2,9	,098
MACS, points	1,52	,246	,569	2,5	,116
B&B Left, blocks/min	1,16	,310	,504	2,2	,148

Table 9. Standardized, Structural and Raw Coefficients and Constant for parameters of Hand function

Variables currently in the model	Standardized	Structural	Raw
Viscous CMT, Newtons	-,657	-,546	-2,050
Sex Index (B=0; G=1)	-1,207	-,449	-2,332
MACS, points	,668	-,262	,996
B&B Left, blocks/min	-,605	,081	-,124
Eigenvalue	,984	**Constant**	,054
r*=0,704; Wilk's Λ=0,504; $x^2_{(4)}$=6,9; p=0,144			
Squared Mahalanobis Distance=5,85; F=1,83; p=0,208			

Figure 7 shows that the roots in which the information about predictors is condensed, in all eleven children with beneficial effects of rehabilitation are higher than those in all three children with beneficial effects, that is, the prediction is unmistakable. However, statistics show its insecure reliability (p=0,144 and 0,208).

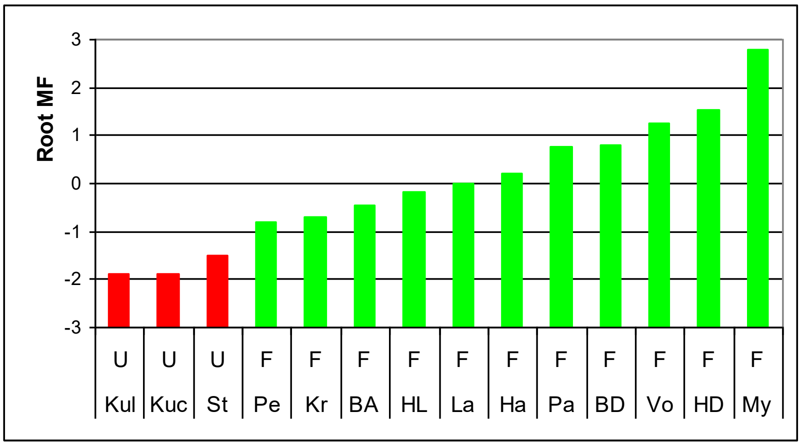

Fig. 7. Individual values of functional predictors of **unfavorable** and **favorable** effects of rehabilitation.

Nevertheless, we give coefficients and constants for prediction of the consequences of rehabilitation for a given set of initial parameters (Table 10).

Instead, seven EEGs parameters as well as the ULF power band of HRV (Tables 11–14, Fig. 8), taken together, provide an opportunity to predict the result of rehabilitation completely reliably.

Table 10. Coefficients and Constants for Classification Functions for parameters of Hand function

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)
Viscous CMT, Newtons	-6,65	-11,24
Sex Index (B=0; G=1)	2,91	-2,31
MACS, points	5,70	7,93
B&B Left, blocks/min	1,32	1,04
Constants	-21,07	-18,22

Table 11. Summary of Stepwise Analysis for EEGs and HRVs parameters

Variables currently in the model	F to enter	p-level	Λ	F-value	p-level
θ-rhythm Asymmetry, %	13,0	,004	,480	13,0	,004
ULF HRV, %	3,1	,104	,373	9,2	,004
F7-β SPD, μV²/Hz	1,2	,307	,335	6,6	,010
O1-β SPD, μV²/Hz	1,7	,226	,282	5,7	,014
T5-δ SPD, %	4,3	,073	,184	7,1	,008
δ-rhythm Asymmetry, %	5,0	,061	,108	9,7	,004
F7-α SPD, μV²/Hz	2,1	,193	,079	10,0	,006
β-rhythm Laterality, %	3,1	,137	,049	12,2	,007

Table 12. Discriminant Function Analysis Summary for EEGs and HRVs parameters

Step 8, N of vars in model: 8; Grouping: 2 grps
Wilks' Lambda: ,0487; approx. $F_{(8,5)}$=12,2; p=0,0068.

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)	Wilks' Λ	Partial Λ	F-remove	p-level	Tolerancy
θ-rhythm Asymmetry, %	51±11	20±4	,052	,929	,4	,564	,248
ULF HRV, %	0,3±0,2	3,7±1,1	,376	,129	33,7	,002	,070
F7-β SPD, μV²/Hz	51±14	138±27	,268	,182	22,5	,005	,027
O1-β SPD, μV²/Hz	88±17	172±31	,279	,175	23,6	,005	,015
T5-δ SPD, %	15±6	39±9	,186	,261	14,1	,013	,060
δ-rhythm Asymmetry, %	74±7	39±6	,147	,331	10,1	,025	,085
F7-α SPD, μV²/Hz	52±22	109±20	,107	,457	6,0	,059	,082
β-rhythm Laterality, %	+43±16	+11±7	,079	,615	3,1	,137	,145

Table 13. Standardized, Structural and Raw Coefficients and Constant for EEGs and HRVs parameters

Variables currently in the model	Standardized	Structural	Raw
θ-rhythm Asymmetry, %	-,547	,235	-,042
δ-rhythm Asymmetry, %	2,883	,193	,161
β-rhythm Laterality, %	1,671	,134	,070
F7-β SPD, μV²/Hz	-5,695	-,108	-,072
ULF HRV, %	-3,613	-,097	-1,043
F7-α SPD, μV²/Hz	2,641	-,092	,043
O1-β SPD, μV²/Hz	7,592	-,091	,084
T5-δ SPD, %	-3,604	-,087	-,136
Eigenvalue	19,54	**Constant**	-8,539
r*=0,975; Wilk's Λ=0,0487; $x^2_{(8)}$=24,2; p=0,0021			
Squared Mahalanobis Distance=116; F=10,1; p=0,0105			

Table 14. Coefficients and Constants for Classification Functions for EEGs and HRVs parameters

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)
θ-rhythm Asymmetry, %	-1,045	-,624
ULF HRV, %	-16,84	-6,435
F7-β SPD, μV²/Hz	-1,228	-,511
O1-β SPD, μV²/Hz	1,444	,610
T5-δ SPD, %	-2,261	-,906
δ-rhythm Asymmetry, %	2,955	1,352
F7-α SPD, μV²/Hz	,805	,372
β-rhythm Laterality, %	1,355	,657
Constants	-147,4	-32,46

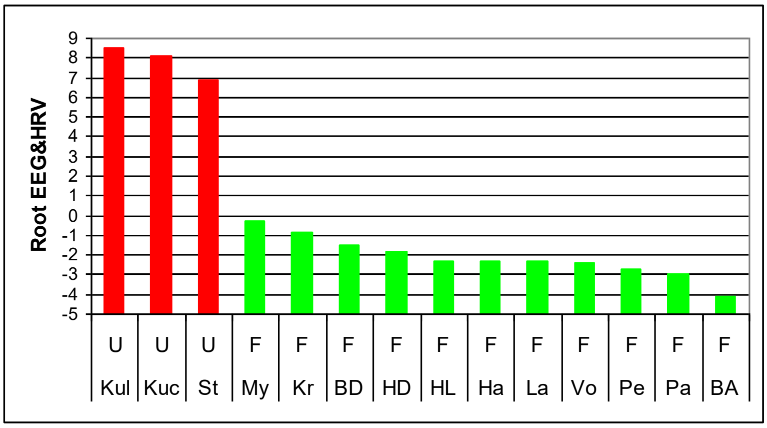

Fig. 8. Individual values of EEGs and HRV predictors of **unfavorable** and **favorable** effects of rehabilitation.

It was found out (Table 12) that the anxiety of the theta- and delta-rhythms is pronounced and the right-hand side of the beta-rhythm lateralization against the background of its low SPD in the left loci, as well as the power of the ULF band of the HRV close to zero.

The following two combinations of predictors make the forecast even more reliable, judging by the increase of D^2_M from 116 to 189 (Tables 15–18 and Figure 9) and 222 (Tables 19–22 and Figure 10).

Table 15. Summary of Stepwise Analysis for Hand function, HRVs and GDVs parameters

Variables currently in the model	F to enter	p-level	Λ	F-value	p-level
Entropy Left (f) GDV	17,9	,001	,401	17,9	,001
BB Right, blocks/min	4,0	,069	,293	13,2	,001
NHP Left, sec	4,5	,060	,202	13,1	$<10^{-3}$
Area Right GDV (f), kPixels	6,2	,035	,120	16,5	$<10^{-3}$
BB Left, blocks/min	5,3	,051	,073	20,4	$<10^{-3}$
ULF HRV, %	2,1	,190	,056	19,7	$<10^{-3}$
Viscous CMT, Newtons	3,1	,131	,037	22,3	$<10^{-3}$
ULF HRV, msec²	1,1	,352	,031	19,8	,002

Table 16. Discriminant Function Analysis Summary for Hand function, HRVs and GDVs parameters

Step 8, N of vars in model: 8; Grouping: 2 grps
Wilks' Lambda: ,0305; approx. $F_{(8,5)}$=19,8; p=0,002.

Variables currently in the model	**Unfavorable changes (3)**	**Favorable changes (11)**	**Wilks' Λ**	**Partial Λ**	**F-remove (1,9)**	**p-level**	**Tole-rancy**
Entropy Left (f) GDV	4,10±0,06	3,82±0,03	,383	,080	57,6	$<10^{-3}$	,080
BB Right, blocks/min	18,8±2,0	14,3±1,8	,308	,099	45,4	,001	,004
NHP Left, sec	64±14	122±23	,071	,431	6,6	,050	,020
Area Right GDV (f), kpixels	32,3±1,6	28,1±0,8	,048	,634	2,9	,150	,242
BB Left, blocks/min	18,7±0,8	13,8±1,6	,101	,301	11,6	,019	,007
ULF HRV, %	0,3±0,2	3,7±1,1	,051	,598	3,4	,126	,029
Viscous CMT, Newtons	0,13±0,05	-0,26±0,11	,055	,551	4,1	,099	,199
ULF HRV, msec²	8±3	76±29	,037	,826	1,1	,352	,070

Table 17. Standardized, Structural and Raw Coefficients and Constant for Hand function, HRVs and GDVs parameters

Variables currently in the model	Standardized	Structural	Raw
Entropy Left (f) GDV	3,452	,217	33,58
Area Right GDV (f), kPixels	1,249	,126	,5
Viscous CMT, Newtons	1,528	,096	4,772
BB Left, blocks/min	-9,891	,079	-2,032
BB Right, blocks/min	14,527	,061	2,532
ULF HRV, %	-3,768	-,076	-1,088
ULF HRV, msec²	1,604	-,062	,0185
NHP Left, sec	5,455	-,064	,0767
Eigenvalue	31,76	**Constant**	-157,9
r*=0,985; Wilk's Λ=0,0305; $x^2_{(8)}$=27,9; p=0,0005			
Squared Mahalanobis Distance=189; F=16,4; p=0,0035			

Table 18. Coefficients and Constants for Classification Functions for Hand function, HRVs and GDVs parameters

Variables currently in the model	**Unfavorable changes (3)**	**Favorable changes (11)**
Entropy Left (f) GDV	5686	5259
BB Right, blocks/min	430,5	398,3
NHP Left, sec	13,93	12,96
Area Right GDV (f), kPixels	86	79
BB Left, blocks/min	-325,0	-299,2
ULF HRV, %	-159,7	-145,9
Viscous CMT, Newtons	697,1	636,4
ULF HRV, msec²	2,581	2,346
Constants	-14516	-12461

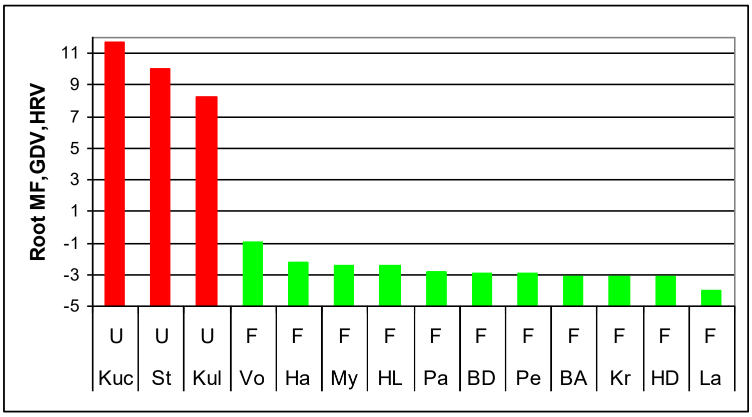

Fig. 9. Individual values of functional. GDVs and HRVs predictors of **unfavorable** and **favorable** effects of rehabilitation.

Table 19. Summary of Stepwise Analysis for EEGs, HRVs and GDVs parameters

Variables currently in the model	F to enter	p-level	Λ	F-value	p-level
Entropy Left (f) GDV	17,9	,001	,401	17,9	,001
θ-rhythm Frequency, Hz	4,1	,067	,292	13,3	,001
ULF HRV, %	1,5	,245	,253	9,8	,003
F7-α SPD, μV²/Hz	1,8	,208	,210	8,4	,004
O1-β SPD, μV²/Hz	2,7	,141	,158	8,5	,005
ULF HRV, msec²	2,3	,170	,118	8,7	,006
δ-rhythm Asymmetry, %	6,5	,044	,057	14,2	,002
Fp1-δ SPD, %	3,0	,141	,035	17,1	,003
F7-θ SPD, %	1,4	,298	,026	16,6	,008

Table 20. Discriminant Function Analysis Summary for EEGs, HRVs and GDVs parameters

Step 9, N of vars in model: 9; Grouping: 2 grps
Wilks' Lambda: ,0260; approx. $F_{(9,4)}$=16,6; p=0,0079.

Variables currently in the model	**Unfavorable changes (3)**	**Favorable changes (11)**	Wilks' Λ	Partial Λ	F-remove	p-level	Tolerancy
Entropy Left (f) GDV	4,10±0,06	3,82±0,03	,210	,124	28,30	,006	,017
θ-rhythm Frequency, Hz	7,33±0,17	6,30±0,42	,087	,300	9,31	,038	,038
ULF HRV, %	0,3±0,2	3,7±1,1	,172	,151	22,45	,009	,005
F7-α SPD, μV²/Hz	52±22	109±20	,133	,196	16,42	,015	,055
O1-β SPD, μV²/Hz	88±17	172±31	,163	,160	21,03	,010	,028
ULF HRV, msec²	8±3	76±29	,134	,195	16,52	,015	,005
δ-rhythm Asymmetry, %	74±7	39±6	,111	,235	12,99	,023	,015
Fp1-δ SPD, %	14±6	33±8	,057	,459	4,72	,096	,021
F7-θ SPD, %	20±3	13±2	,035	,737	1,43	,298	,173

Table 21. Standardized, Structural and Raw Coefficients and Constant for EEGs, HRVs and GDVs parameters

Variables currently in the model	Standardized	Structural	Raw
Entropy Left (f) GDV	7,347	,200	71,48
δ-rhythm Asymmetry, %	-7,150	,139	-,398
F7-θ SPD, %	-1,249	,093	-,213
θ-rhythm Frequency, Hz	4,331	,061	3,605
ULF HRV, %	-13,28	-,070	-3,833
F7-α SPD, μV²/Hz	-3,861	-,066	-,064
O1-β SPD, μV²/Hz	5,579	-,066	,061
ULF HRV, msec²	12,52	-,057	,144
Fp1-δ SPD, %	-5,117	-,054	-,207
Eigenvalue	37,42	**Constant**	-273,8
r*=0,987; Wilk's Λ=0,0260; $x^2_{(9)}$=27,4; p=0,0012			
Squared Mahalanobis Distance=222; F=13,7; p=0,0113			

Table 22. Coefficients and Constants for Classification Functions for EEGs, HRVs and GDVs parameters

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)
Entropy Left (f) GDV	22266	21279
θ-rhythm Frequency, Hz	1088	1038
ULF HRV, %	-1173	-1120
F7-α SPD, μV²/Hz	-18,00	-17,13
O1-β SPD, μV²/Hz	18,02	17,17
ULF HRV, msec²	45,22	43,23
δ-rhythm Asymmetry, %	-129,8	-124,3
Fp1-δ SPD, %	-67,01	-64,15
F7-θ SPD, %	-78,40	-75,45
Constants	-43852	-40017

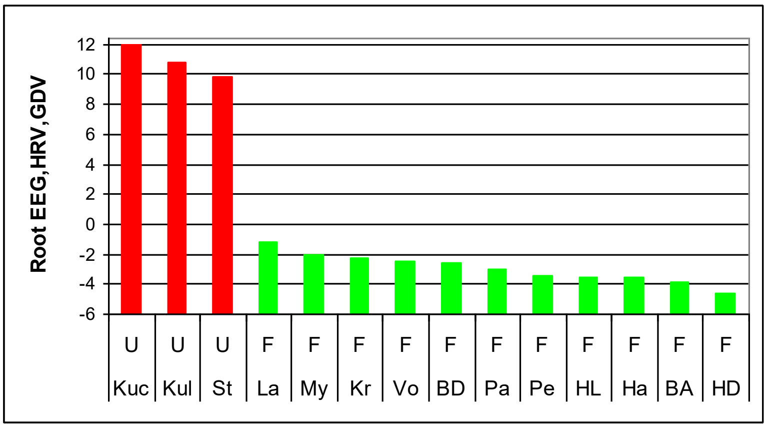

Fig. 10. Individual values of EEGs, HRVs and GDV predictors of **unfavorable** and **favorable** effects of rehabilitation.

The set of eight predictors, which includes representatives of all research methods (Table 23), was the most reliable in forecasting. The most informative, judging by the Λ and Structural coefficient, was the Entropy of the gas-discharge image (filmed with the filter) in the **left** projection (Table 23 and 24). It, as well as the frequency of theta-rhythm, were significantly higher in children with an unfavorable effect of rehabilitation. Instead, the SPD beta- and alpha-rhythms in the two **left** loci of these children, as well as the power of the ULF band of the HRV, were significantly lower (Table 25).

Table 23. Summary of Stepwise Analysis for optimal set of parameters. The scale of ranks for variables

Variables currently in the model	F to enter	p-level	Λ	F-value	p-level
Entropy Left (f) GDV	17,9	,001	,401	17,9	,0012
θ-rhythm Frequency, Hz	4,1	,067	,292	13,3	,0012
B&B Right, blocks/min	8,4	,016	,159	17,6	,0003
F7-α SPD, μV²/Hz	2,4	,159	,126	15,6	,0004
O1-β SPD, μV²/Hz	5,5	,047	,075	19,9	,0003
ULF HRV, %	1,7	,236	,060	18,2	,0006
ULF HRV, msec²	2,7	,154	,042	19,7	,0010
F7-β SPD, μV²/Hz	4,4	,090	,022	27,5	,0010

Table 24. Standardized, Structural and Raw Coefficients and Constant for optimal set of parameters

Variables currently in the model	Standardized	Structural	Raw
1	2	3	4
Entropy Left (f) GDV	2,871	,184	27,93
θ-rhythm Frequency, Hz	4,210	,056	3,505
B&B Right, blocks/min	1,868	,052	,326
F7-β SPD, μV²/Hz	-2,003	-,072	-,025
ULF HRV, %	-6,490	-,064	-1,873

Table 24

1	2	3	4
F7-α SPD, μV²/Hz	-2,593	-,061	-,043
O1-β SPD, μV²/Hz	5,350	-,060	,059
ULF HRV, msec²	4,937	-,053	,057
Eigenvalue	44,06	**Constant**	-136,1
r*=0,989; Wilk's Λ=0,0222; $x^2_{(8)}$=30,5; p=0,0002			
Squared Mahalanobis Distance=262; F=22,7; p=0,0016			

Table 25. Discriminant Function Analysis Summary for optimal set of parameters

Step 8, N of vars in model: 8; Grouping: 2 grps
Wilks' Lambda: ,0222; approx. $F_{(8,5)}$=27,5; p=0,0010.

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)	Wilks' Λ	Partial Λ	F-remove	p-level	Tolerancy
Entropy Left (f) GDV	4,10±0,06	3,82±0,03	,367	,061	78	$<10^{-3}$	,117
θ-rhythm Frequency, Hz	7,33±0,17	6,30±0,42	,212	,105	43	,001	,052
B&B Right, blocks/min	18,8±2,0	14,3±1,8	,071	,313	11	,021	,201
F7-α SPD, μV²/Hz	52±22	109±20	,076	,291	12	,017	,108
O1-β SPD, μV²/Hz	88±17	172±31	,117	,189	21	,006	,029
ULF HRV, %	0,3±0,2	3,7±1,1	,069	,321	11	,023	,016
ULF HRV, msec²	8±3	76±29	,057	,391	8	,038	,026
F7-β SPD, μV²/Hz	51±14	138±27	,042	,532	4	,090	,119

The maximum difference between clusters by the combination of these predictors is illustrated in Figure 11.

The forecast is realized by the coefficients and constants given in Table 26.

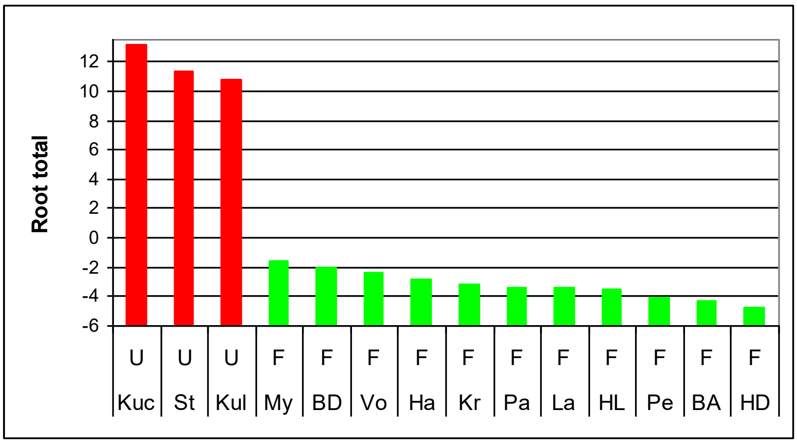

Fig. 11. Individual values of optimal set of predctors of **unfavorable** and **favorable** effects of rehabilitation.

Table 26. Coefficients and Constants for Classification Functions for optimal set of parameters

Variables currently in the model	Unfavorable changes (3)	Favorable changes (11)
Entropy Left (f) GDV	4242	3824
θ-rhythm Frequency, Hz	515,9	463,4
B&B Right, blocks/min	49,41	44,53
F7-α SPD, μV²/Hz	-6,20	-5,56
O1-β SPD, μV²/Hz	8,53	7,65
ULF HRV, %	-265,0	-236,9
ULF HRV, msec²	8,15	7,30
F7-β SPD, μV²/Hz	-3,48	-3,10
Constants	-11168	-9064

Conclusion. Despite the small contingent of the observed children with spastic form of cerebral palsy, we have proved that the differently directed changes in the parameters of manual tests caused by two-week rehabilitation course by Kozyavkin© method are due to differently directed changes in parameters of EEG, HRV as well as GDV. The character of the changes in the parameters of the motor function of the hands is conditioned both by their initial level and by the set of parameters of EEG, HRV and GDV and is subject to reliable prediction. Increasing the effectiveness of rehabilitation, perhaps, is possible through additional electrostimulation of the vagus nerve and/or certain scalp loci. GDV is a completely suitable non-invasive method for assessing the effectiveness of rehabilitation.

Acknowledgment. We express our sincere gratitude to Doctors Forssberg H, Gäverth J and Fagergren A for studying and consulting on working with the device "NeuroFlexor" as well as to administration JSC "Truskavets'kurort" for help in recording EEG and HRV.

Accordance to ethics standards. Tests in patients are conducted in accordance with positions of Helsinki Declaration 1975, revised and complemented in 2002, and directive of National Committee on ethics of scientific researches. During realization of tests from parents all participants the informed consent is got and used all measures for providing of anonymity of participants.

For all authors any conflict of interests is absent.

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ПРОГНОЗУВАННЯ ЗМІН МОТОРНОЇ ФУНКЦІЇ РУК ВНАСЛІДОК ЗАСТОСУВАННЯ МЕТОДУ КОЗЯВКІНА® У ДІТЕЙ ІЗ СПАСТИЧНОЮ ФОРМОЮ ЦЕРЕБРАЛЬНОГО ПАРАЛІЧУ ЗА ЇХ ПОЧАТКОВИМ РІВНЕМ, ПОКАЗНИКАМИ ЕЛЕКТРОЕНЦЕФАЛОГРАМИ, ВАРІАБЕЛЬНОСТІ СЕРЦЕВОГО РИТМУ ТА ГАЗОРОЗРЯДНОЇ ВІЗУАЛІЗАЦІЇ

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РЕЗЮМЕ. Раніше ми повідомляли, що у дітей із спастичною формою церебрального паралічу (СФЦП) після двотижневого курсу реабілітації методом Козявкіна© тести на моторну функцію рук змінювалися неоднозначно (у 11 із 14 поліпшувались, проте у 3 погіршувалися), і такі зміни супроводжувалися різноспрямованими змінами низки параметрів ЕЕГ, варіабельності ритму серця (ВРС) та газорорядної візуалізації (ГРВ).

Мета дослідження – виявити особливості змін параметрів ЕЕГ, ВРС і ГРВ у дітей зі сприятливими і несприятливими змінами параметрів моторної функції рук, а також з'ясувати можливість передбачити характер змін моторної функції рук за сукупністю початкових параметрів організму.

Матеріал і методи. Об'єктом спостереження було 14 дітей (6 дівчаток та 8 хлопчиків) у віці 8–15 років з СФЦП. Стан моторного розвитку за шкалою GMFCS був на рівні II÷IV. Функціональний стан рук за шкалою MACS був на рівні II÷III. Оцінка функції рук здійснювалася за допомогою динамометрії (D), тесту «коробка і блоки» (BB) та тесту «дев'ять лунок і кілків» (NHP). Ми реєстрували також компоненти м'язового тонусу за допомогою пристрою «NeuroFlexor» (Aggero MedTech AB, Швеція), параметри ВРС та ЕЕГ одночасно за допомогою апаратно-програмних комплексів «Cardiolab + VSR» та «NeuroCom Standard» (ХАІ Медика, Харків, Україна), а також параметри ГРВ «GDV Chamber» («Biotechprogress», СПб, РФ).

Результати. Методом дискримінантного аналізу з'ясовано, що прогнозування лише за статтю, шкалою MACS, BB тестом лівої руки і в'язкою компонентою м'язового тонусу, попри безпомилковість, все ж недостатньо надійне (квадрат віддалі Mahalanobis D2M між кластерами 6,85; p=0,208). Натомість дискримінантна модель на основі 7 параметрів ЕЕГ і ULF смуги ВРС вже цілком надійна (D^2_M=116; p=0,011). Додаткове включення у модель параметра ГРВ веде до подальшого підвищення надійності прогнозу (D^2_M=222; p=0,011), котра сягає максимуму при врахуванні BB тесту правої руки (D^2_M=262; p=0,002).

Висновок. Характер змін параметрів моторної функції рук внаслідок курсу реабілітації методом Козявкіна© кондиціонується як їх початковим рівнем, так і сукупністю параметрів ЕЕ, ВРС і ГРВ і піддається надійному прогнозуванню.

КЛЮЧОВІ СЛОВА: церебральний параліч; динамометрія; тести «коробка і блоки» та «дев'ять лунок і кілків»; нервовий, еластичний і в'язкий компоненти м'язового тонусу; електроенцефалограма, варіабельність ритму серця, газорозрядна візуалізація, система інтенсивної нейрофізіологічної реабілітації Козявкіна©.

ПРОГНОЗИРОВАНИЕ ИЗМЕНЕНИЙ МОТОРНОЙ ФУНКЦИИ РУК В РЕЗУЛЬТАТЕ ПРИМЕНЕНИЯ МЕТОДА КОЗЯВКИНА® У ДЕТЕЙ СО СПАСТИЧЕСКОЙ ФОРМОЙ ЦЕРЕБРАЛЬНОГО ПАРАЛИЧА ПО ИХ НАЧАЛЬНОМУ УРОВНЮ, ПОКАЗАТЕЛЯМ ЭЛЕКТРОЭНЦЕФАЛОГРАММЫ, ВАРИАБЕЛЬНОСТИ СЕРДЕЧНОГО РИТМА И ГАЗОРАЗРЯДНОЙ ВИЗУАЛИЗАЦИИ

О. В. Козявкина[1], Н. В. Козявкина[1], М. С. Гордиевич[1], Т. Б. Волошин[1], В. И. Лисович[1], В. Й. Бабелюк[2], Г. И. Дубкова[2], Т. А. Королишин[2,5], Д. В. Попович[3], И. Р. Мисула[3], Н. И. Сидлярук[3], В. Жуков[4], И. Л. Попович[1,5]

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РЕЗЮМЕ. Ранее мы сообщали, что у детей со спастической формой церебрального паралича (СФЦП) после двухнедельного курса реабилитации по методу Козявкина© тесты на моторную функцию рук менялись неоднозначно (у 11 из 14 улучшались, однако у 3 ухудшались), и такие изменения сопровождались разнонаправленными изменениями ряда параметров ЭЭГ, вариабельности ритма сердца (ВРС) и газорозрядной визуализации (ГРВ).

Цель исследования – выявить особенности изменений параметров ЭЭГ, ВРС и ГРВ у детей с благоприятными и неблагоприятными изменениями параметров моторной функции рук, а также выяснить возможность предсказать характер изменений моторной функции рук по совокупности начальных параметров организма.

Материал и методы. Объектом наблюдения было 14 детей (6 девочек и 8 мальчиков) в возрасте 8–15 лет с СФЦП. Состояние моторного развития по шкале GMFCS было на уровне II ÷ IV. Функциональное состояние рук по шкале MACS было на уровне II ÷ III. Оценка функции рук осуществлялась с помощью динамометрии (D), теста «коробка и блоки» (BB) и теста «девять лунок и кольев» (NHP). Мы регистрировали также компоненты мышечного тонуса с помощью устройства «NeuroFlexor» (Aggero MedTech AB, Швеция), параметры ВРС и ЕЕГ одновременно с помощью аппаратно-программного комплекса «Cardiolab + VSR» и «NeuroCom Standard» (ХАИ Медика, Харьков, Украина), а также параметры ГРВ «GDV Chamber» («Biotechprogress», СПб, РФ).

Результаты. Методом дискриминантного анализа выяснено, что прогнозирование только по полу, шкале MACS, BB тестом левой руки и вязкой компонентой мышечного тонуса, несмотря на безошибочность, все же недостаточно надежное (квадрат расстояния Mahalanobis D^2_M между кластерами 6,85; p=0,208). Зато дискриминантная модель на основе 7 параметров ЭЭГ и ULF полосы ВРС уже вполне надежна (D^2_M=116; p=0,011). Дополнительное включение в модель параметра ГРВ ведет к дальнейшему повышению надежности прогноза (D^2_M=222; p=0,011), которая достигает максимума при учете BB теста правой руки (D^2_M=262; p=0,002).

Вывод. Характер изменений параметров моторной функции рук в результате курса реабилитации по методу Козявкина© кондиционируется как их начальным уровнем, так и совокупностью параметров ЭЭ, ВРС и ГРВ и подвергается надежному прогнозированию.

КЛЮЧЕВЫЕ СЛОВА: церебральный паралич; динамометрия; тесты «коробка и блоки» и «девять лунок и кольев»; нервный, эластичный и вязкий компоненты мышечного тонуса, электроэнцефалограмма, вариабельность ритма сердца, газоразрядная визуализация, система интенсивной нейрофизиологической реабилитации Козявкина©.

Отримано 14.11.2018