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EFFECT OF SPINE BIOMECHANICAL CORRECTION KOZYAVKIN's METHOD (INRS) ON COMPONENTS OF MUSCLE TONE IN CHILDREN WITH SPASTIC FORM OF CEREBRAL PALSY AND ITS POSSIBLE PREDICTION

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Abstract

A clinical-physiological observations in 29 children aged 7÷16 years with spastic forms of cerebral palsy. State of Gross Motor Function was 1÷4 levels at GMFCS, the functional state of the hand (usually the left) was 1÷4 levels at MACS, hand spasticity estimated in the range 0÷2 on a scale Åshworth (ASS). Neural component of muscle tone (N), registered device Neuroflexor, was in the range 0,48÷18,08, elastic component (E) ranging -1,80÷4,36, and its viscous component (V) ranging -0,80÷0,73. We found a strong correlation between N and ASS (r=0,74), GMFCS (r=0,66), MACS (r=0,66), whereas the correlation of these parameters E on the verge of significance (r=0,36; 0,32, 0,34), and V all with their not related (r=0,14; 0,00; -0,15). After 10-15 min after the first spine biomechanical correction Kozyavkin' method N in 17 children decreased from 7,6±1,1 by 3,4±0,7 (p<0,001), in 4 children has not significantly changed: 2,9±1,7 to and 2,5±1,6 after correction, and in 8 cases increased from 5,8±2,1 by 2,2±0,7 (p<0,01). After a two-week course of rehabilitation by Kozyavkin's method reducing N stated in 23 (79,3%) children from 7,6±1,0 by 6,0±0,8 (p<0,001). In 4 (13,8%) children changes were not detected: 1,6±0,6 to and 2,0±0,7 after treatment, however, in 2 cases N increased from 1,6 to 3,4 and from 4,6 to 6,1. Multiple regression equation to calculate the expected value of N as after the first correction of the spine, and after a two-week course of rehabilitation Kozyavkin's method. The method of discriminant analysis revealed that the nature of emergency response N at correcting the spine is projected for a range of initial parameters to within 72,4% and accuracy of predictions on the nature of the reaction of N treatment is 93,1%.

Keywords: cerebral palsy, neural, elastic and viscous components of muscle tone, Intensive Neurophysiological Rehabilitation by Kozyavkin, prediction.

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INTRODUCTION

Currently, there are a number of methods of rehabilitation of patients with cerebral palsy. One of the new methods of recovery, which is increasingly used in clinical practice is Intensive Neurophysiological Rehabilitation (INRS), also known by the name of its author as Kozyavkin's method. The cornerstone of the system is a biochemical correction of the spine and large joints and superstructure - a complex of therapeutic measures, such as reflexology, mobilization of joints and extremities, physiotherapy, massage, rhythmic gymnastics, hydrotherapy, apitherapy. Versatile effects of this treatment are mutually reinforcing and are directed at achieving the main goal of rehabilitation - improving the quality of life for patients. By stimulating compensatory possibilities child's body and brain plasticity INRS activated in the body of the child creates a new functional status, normalizes muscle tone, restores joint mobility, improves circulation and trophic levels, which opens up possibilities for a faster motor and mental development of children [8,9,]. Cabinet of Ministers of Ukraine of 20.08.93, № 622 INRS recommended for implementation of hospitals Ukraine. During this period of rehabilitation were more than 30,000 patients from 53 countries. According to previous studies, the effectiveness of INRS significantly higher than global counterparts. Members of the Executive Committee of the International Child Neurology Association in the resolution of the International and IX Ukrainian Congress of Child Neurology expressed their opinion on the effectiveness of joint research of rehabilitation of patients with organic diseases of the nervous system and the creation of an ad hoc working group of international experts. In this paper we present the first results of research in the international project on the impact of INRS in muscle tone of children with spastic forms of cerebral palsy.

MATERIAL AND METHODS

The object of clinical-physiological observations were 29 children aged 7÷16 years with spastic forms of cerebral palsy (usually spastic tetraparesis, in 7 – hemiparesis, in 1 – tryparez, in 1 - diplegia). State motor development at Gross Motor Function Classification System (GMFCS) [1,4,17,18,21] the majority was on the second level, 9 - the third, in the 8 - the first, in the 1 - to the fourth level. Functional status of the hand (usually the left, 4 - right) with Manual Ability Classification Scale (MACS) [2] was in the majority at the second level, 5 - the first, in the 5 - to third, 2 - on the fourth level. The spasticity hands behind Åshworth Scale [3] evaluated most children as 1, in 8 - as 2, in 1 - as 0. Registration muscle tone held device "*Neuroflexor*", which makes it possible to quantify the various components of muscle tone and isolate neural component that is actually responsible for spasticity [7]. According to a standardized protocol, patients underwent first demonstration of fast and slow movements of the device. Then the patient's arm was fixed in gear with the help of four elastic retainers and two reference points on the elements of the device. Each survey was created on a computer separate folder, where all data is stored. By default examined left hand , but the superiority of spastic component to the right, and right-sided hemiparesis in the presence examined right hand, which necessarily recorded in the protocol. Repeated surveys necessarily used the same hand. Has first one quick motion, then 5 slow and 10 rapid movements (with fixed arm of the patient). Then conducted 4 fast and 4 slow motion. On the final analysis excluded values of the first and second fast motion without fixing hand, the first slow motion without fixing the hand and arm fixed. Registration muscle tone held three times: on admission to the clinic, 10-15 minutes after the first spine biomechanical correction Kozyavkin's method and after a two-week rehabilitation course.

Digital material is treated by methods factor [5], discriminant [6], variation, cross-correlation, canonical analyses with the use of package of softwares "Statistica-5.5" and algorithm of Truskavets' scientific school of balneology [11-16, 19,20].

RESULTS AND DISCUSSION

A factor analysis is applied by us with the purpose of reduction of number of variables (reductions of data) determination of structure of intercommunications between variables, id est their classifications. From the row of methods of factor analysis the analysis of principal components (PC) is involved [5]. It is considered that for the study of factor structure of the investigated field it is possible to be limited to consideration of such amount of PC, the total contribution of which to general dispersion of weekend of data exceeds 2/3. For achievement of more simple interpretation of decisions used, as known, conception of oblique (unorthogonal) factors, which enables better to present the clusters of variables without abandonment from orthogonal (independences) factors. Therefore after determination of clusters variable rotary presses of axes within the limits of clusters by us the calculation of correlations was conducted between the found oblique factors. Results testify for mutual independence of factors. With the purpose of being of matrix of factor reflection, the nearest to the simplest ideal structure, procedure of orthogonal rotary press is conducted by the methods of quartimax, varimax and equamax. We are choose the method of equamax, which combines properties of two first [19].

Evidently (table. 1), that first PC explains the maximal part of changeability (variance) of the informative field and can be interpreted as the levels of Gross Motor Function, Manual Ability and Spasticity. It is important, that **maximal** factor loadings gives initial **neural** component of muscle tone. Second PC characterizes elastic component of muscle tone, while third PC characterizes viscous component and age of child.

Thus, to 70% informations about 10 initial parameters of children can be condensated in 3 principal components. The summary of factor analysis are visualized on fig. 1.

We turn to the analysis of relationships between different initial parameters kids. First of all, we confirmed a close relationship (r=0,65) between initial levels of Gross Motor Function Classification System and Manual Ability Classification System. The relationship more precisely approximated by second degree function (fig. 2).

We confirmed also relationships between initial levels of muscle tone neural component and Åshworth Spasticity Scale (r=0,74), as well as GMFCS (r=0,66) and MACS (r=0,66) (fig. 3).

Table 1. Factor analysis of initial parameters. Factor Loadings (Equamax normalized). Clusters of loadings are marked; those clusters determine the oblique factors for hierarchical analysis. Extraction: Principal components

Parameters	Factor 1	Factor 2	Factor 3
Neural Component Initial (NI)	**0,877**	*0,126*	*0,197*
Åshworth Spasticity Scale	**0,866**	*0,134*	*0,119*
GMFCS level	**0,839**	*0,125*	*-0,064*
Neural Component after Correction (NC)	**0,831**	*-0,136*	*0,078*
MACS level	**0,815**	*0,133*	*-0,270*
Elastic Component after Correction (EC)	*0,162*	**0,856**	*0,039*
Elastic Component Initial(EI)	*0,295*	**0,721**	*-0,037*
Viscous Component after Correction (VC)	*-0,035*	0,625	*0,180*
Viscous Component Initial (VI)	*0,059*	*0,003*	**0,894**
Age	*0,036*	*0,377*	0,698
Explained Variance	**3,696**	**1,872**	**1,457**
Prp. Total	**0,369**	**0,187**	**0,146**
Eigenvalue	**3,940**	**1,871**	**1,214**
Cumulated Eigenvalue	**3,940**	**5,811**	**7,026**
% total Variance	**39,4**	**18,7**	**12,1**
Cumulated %	**39,4**	**58,1**	**70,3**

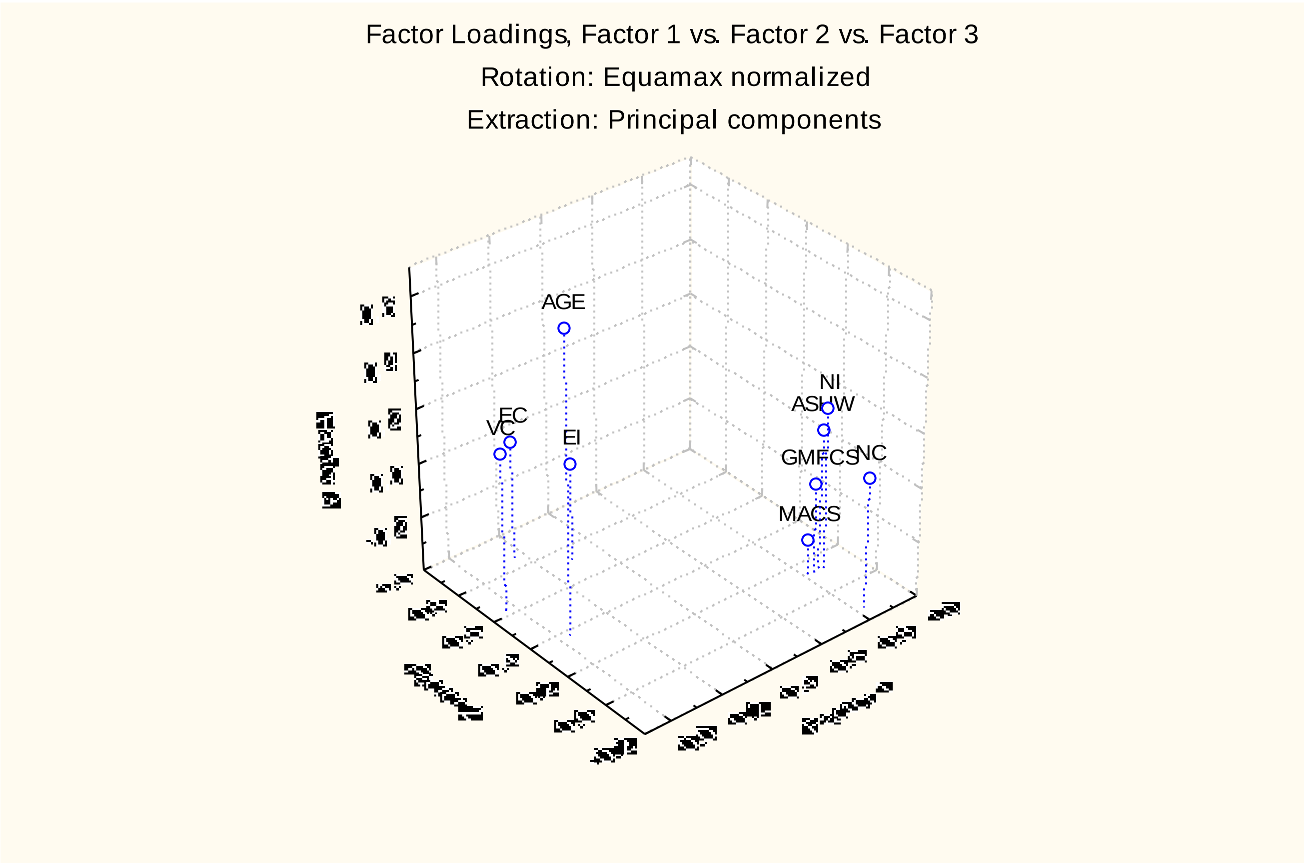


Fig. 1. 3D visualization factor loadings of initial parameters

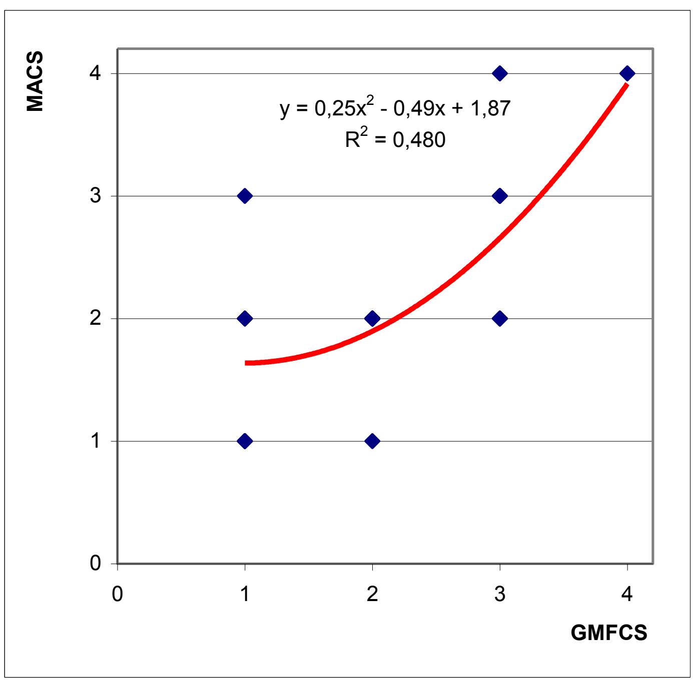


Fig. 2. Relationships between initial levels of Gross Motor Function Classification System (axis X) and Manual Ability Classification System (axis Y)

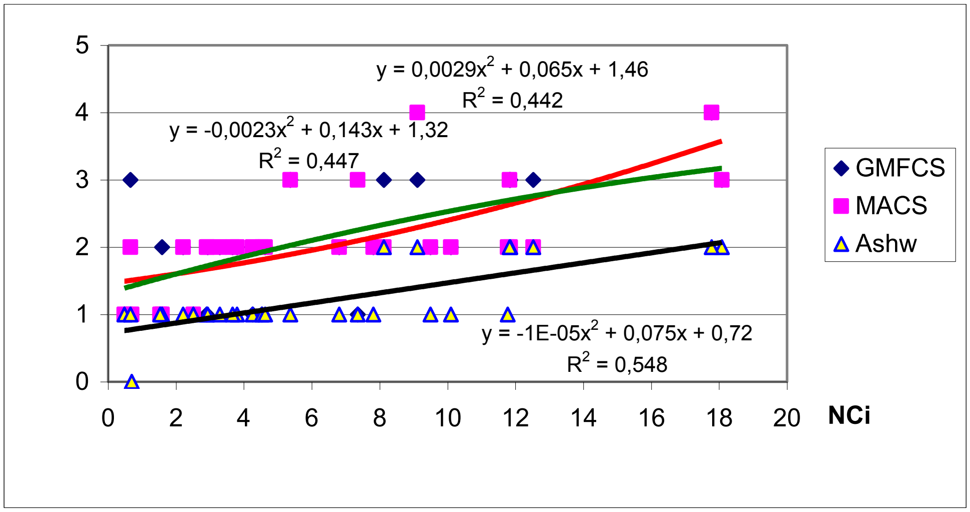


Fig. 3. Relationships between initial levels of muscle tone neural component (NCi) (axis X) and Åshworth Spasticity Scale, GMFCS, MACS (axis Y)

On other hand, it is detected that muscle tone elastic component correlates with these parameters moderately (r=0,36; 0,32; 0,34), i.e. it is determined by both GMFCS and MACS levels very weakly, on 14% and 21% correspondently only (fig. 4).

The determination of muscle tone viscous component by both GMFCS and MACS levels is almost lack (fig. 5).

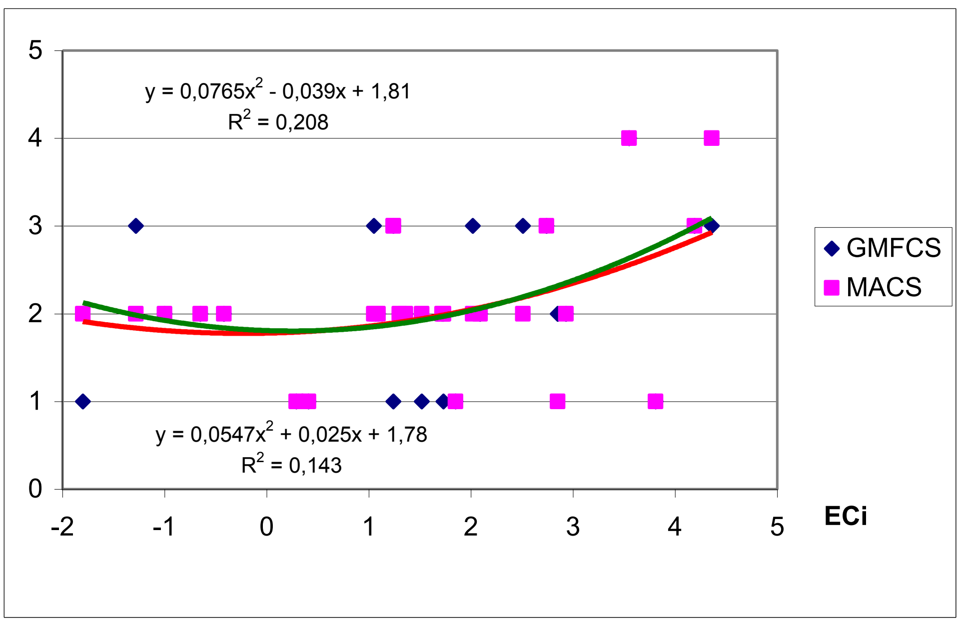


Fig. 4. Relationships between initial levels of muscle tone elastic component (ECi) (axis X) and GMFCS, MACS (axis Y)

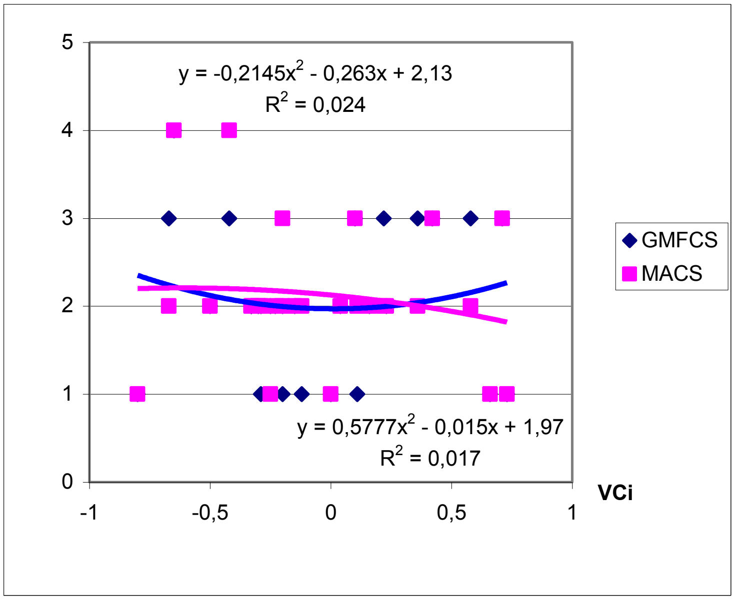


Fig. 5. Relationships between initial levels of muscle tone viscous component (VCi) (axis X) and GMFCS, MACS (axis Y)

For further analysis was retrospectively formed three groups of children based on the changes of muscle tone neural component after course of rehabilitation by Kozyavkin's method. Reduced muscle tone neural component stated in 23 (79,3%) children. In 4 (13,8%) children had no significant changes were found. However, at 2 children muscle tone neural component increased (table 2). The decrease in muscle tone neural component after a course of rehabilitation by 79% followed reduction in this parameter after the first correction of the spine by 27%. Instead, no change muscle tone neural component in 4 children pronounced as after the first correction, and after their course. However noteworthy that in these children the average value of this parameter has on admission was the same as the end of the first group. This is consistent with the "law baseline (initial level)" by which initially normal parameters influenced by **physiological** stimuli almost unchanged. Correct statistical analysis of the increase in muscle tone neural component at 2 kids from 1,6 to 3,4 and from 4,6 to 6,1 is not yet possible due to scarcity of the sample, but this fact deserves attention in the future.

Regarding muscle tone **elastic** (table 3) and **viscous** (table 4) components of regular changes were detected neither after the first adjustment nor after a course of rehabilitation.

It seems that these parameters can be neglected as uninformative (as we shall see later, the first impression turned out to be false).

Table 2. Relationships between changes of muscle tone neural component after one correction and after course of treatment at children with various effectiveness by Kozyavkin's method

Muscle tone component	Decreasing effect (23)	Neutral effect (4)	Increasing effect (2)	p_{1-2}	p_{1-3}	p_{2-3}
Neural initial	7,62±1,00	1,58±0,59	3,11±1,52	<0,001	=0,02	>0,3
Neural after one correction	5,55±0,98	3,58±1,96	1,51±0,52	>0,3	<0,01	>0,5
Neural after course of treatment	1,59±0,48	2,02±0,69	4,76±1,33	>0,5	<0,05	>0,5
Urgent change for neural component	-2,06±0,72 p<0,01	+2,00±1,51 p>0,2	-1,60±1,00 p>0,2	<0,05	>0,5	>0,1
Course change for neural component	-6,03±0,83 p<0,001	+0,44±0,24 p>0,1	+1,65±0,19 p<0,02	<0,001	<0,001	<0,02

Table 3. Accompanying changes of muscle tone elastic component at children with various changes of muscle tone neural component after course of treatment by Kozyavkin's method

Muscle tone component	Decreasing effect (23)	Neutral effect (4)	Increasing effect (2)	p_{1-2}	p_{1-3}	p_{2-3}
Elastic initial	1,53±0,31	1,01±1,18	2,11±0,74	>0,5	>0,5	>0,5
Elastic after one correction	2,06±0,33	1,82±1,15	1,34±0,07	>0,5	<0,05	>0,5
Elastic after course of treatment	0,97±0,32	-0,62±0,90	-0,18±1,61	>0,1	>0,5	>0,5
Urgent change for elastic component	+0,52±0,36 p>0,1	+0,82±0,60 p>0,2	-0,77±0,68 p>0,5	>0,5	>0,5	>0,5
Course change for elastic component	-0,54±0,41 p>0,1	-1,63±0,85 p>0,1	-2,29±0,86 p>0,1	>0,2	>0,1	>0,5

Table 4. Accompanying changes of muscle tone viscous component at children with various changes of muscle tone neural component after course of treatment by Kozyavkin's method

Muscle tone component	Decreasing effect (23)	Neutral effect (4)	Increasing effect (2)	p_{1-2}	p_{1-3}	p_{2-3}
Viscous initial	-0,08±0,08	0,26±0,25	-0,28±0,02	>0,2	<0,05	>0,1
Viscous after one correction	-0,59±0,54	-0,06±0,16	-0,30±0,05	>0,2	>0,2	>0,5
Viscous after course of treatment	-0,13±0,08	0,58±0,30	-0,02±0,13	<0,05	>0,2	>0,2
Urgent change for viscous component	-0,51±0,53 p>0,2	-0,32±0,18 p>0,1	-0,02±0,03 p>0,5	>0,5	>0,5	>0,5
Course change for viscous component	-0,05±0,12 p>0,5	+0,32±0,30 p>0,5	+0,26±0,15 p>0,5	>0,5	>0,1	>0,5

In order to identify the parameters which change specific accompanied to various course effects on neural component of muscle tone, was conducted discriminant analysis (method forward stepwise [Klecka WR, 1989]). The program is included in model 3 discriminant variables, other 3 variables currently not in the model (Table 5).

Table 5. Results of discriminant analysis of parameters which change specific accompanied to various course effects on neural component of muscle tone

Wilks' Lambda: 0,458; approx. $F_{(6,48)}=3{,}81$; p=0,0035

Variables	Wilks' Lambda	Partial Lambda	F-remove (2,24)	p-level	Tole-rancy
Change for neural component after course	0,757	0,605	7,821	0,002	0,695
Change for elastic component after course	0,546	0,8394	2,302	0,122	0,923
Change for neural component after correction	0,508	0,901	1,310	0,288	0,745

Variables currently not in the model

Degree freedom for all F-tests: 2,23

Variables	Wilks' Lambda	Partial Lambda	F to enter	p-level	Tole-rancy
Change for elastic component after correction	0,436	0,952	0,585	0,565	0,963
Change for viscous component after correction	0,440	0,959	0,488	0,620	0,739
Change for viscous component after course	0,454	0,990	0,112	0,894	0,984

The discriminant information is condensed in two canonical roots. The major root contents 88,3% discriminant possibilities and, as evidenced by the structural coefficients for canonical variables (correlations variables-canonical roots), inversely representes change for neural component after course, but by straight modus representes change for viscous component. The minor root contents 11,7% discriminant possibilities and by straight modus representes change for neural component after one correction. The calculation of values of individual unstandardized canonical scores of roots by summation the multiplications of individual variables on the raw coefficients for canonical variables plus constants (Table 6) allows vizualisation all the children on the plane of the two roots (Fig. 6).

Table 6. The characteristics of parameters which change specific accompanied to various course effects on neural component of muscle tone

Discriminant variables currently in the model	Parameters of Wilks' statistics			Coefficients for canonical variables				Means of predictors of different urgent effects		
	Λ	F	p	Raw		Structural		Decrease n=23	Neutral n=4	Increase n=2
				Root 1	Root 2	Root 1	Root 2			
d NC after course	0,604	8,53	0,001	-0,30	-0,06	**-0,83**	0,38	-6,0±0,8	+0,4±0,2	+1,65±0,2
d EC after course	0,509	5,05	0,002	0,42	0,27	**0,30**	0,39	-0,5±0,4	-1,6±0,8	-2,3±0,9
d NC after I correc.	0,459	3,83	0,003	0,06	0,30	-0,30	**0,93**	-2,1±0,7	+2,0±1,5	-1,6±1,0
Chi-square tests with successive roots removed	**Constant**			**-0,93**	**0,37**					
	r_1^*=0,70; Wilks' Λ=0,46; $\chi^2_{(6)}$=19,5; p=0,003						Root 1	+0,45	-1,37	-2,46
	r_2^*=0,33; Wilks' Λ=0,89; $\chi^2_{(2)}$=2,9; p=0,23						Root 2	-0,04	+0,67	-0,84

Figure 6 illustrates that children with decrease of muscle tone **neural** component after course of rehabiliation accompanied minimal change of muscle tone **elastic** component rank along the axis Root 1 rightmost area (centroide: +0,45) while children with **increase** of muscle tone neural component accompanied tendency to **decrease** of muscle tone elastic component occupy the leftmost area (centroide: -2,46). Children with uncertain changes of muscle tone **neural** component after course of rehabiliation occupy an intermediate position axially Root 1 (centroide: -1,37), and Root 2-axis highest (centroide: +0,67), reflecting the tendency to **increase** of muscle tone neural component after **one** correction, whereas the other two groups characteristic tendency to **decrease** in this parameter. So, change of muscle tone **elastic** component after course of rehabiliation still has some informative.

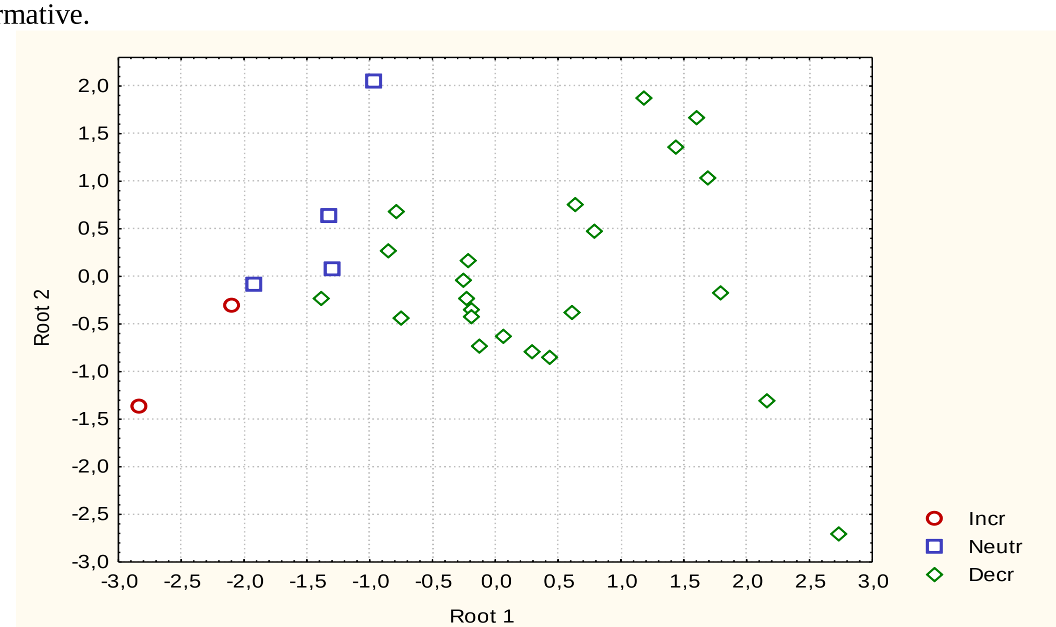


Fig. 6. Unstandardized canonical scores of roots of parameters characterized various course effects on muscle tone neural component

Analysis of individual changes, visualized in fig.7, shows that the level of muscle tone neural component after **one** correction closely (r=0,72) related to its initial level, that is determined by its on 52%. Instead, level of muscle tone neural component after course of rehabilitation is determined by its initial level on 15 % only (r=0,39).

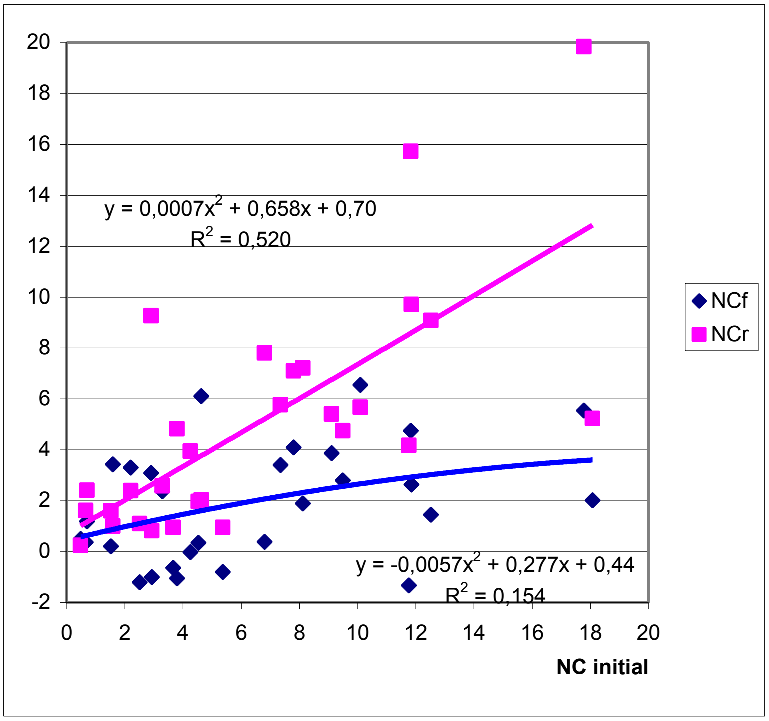


Fig. 7. Relationships between initial level of muscle tone neural component (NCi) (axis X) and its after one correction (NCr) as well as after course of treatment (NCf)(axis Y)

It is detected that at children with initial level of muscle tone neural component less than 3 it increases or unchanged, while at children with hypertone it desreases (fig. 8). On the whole, reaction muscle tone to firtht correcting manipulation is the significantly, the highest its initial level (r=-0,46), i.e. reactive change is determined by initial level on 21%.

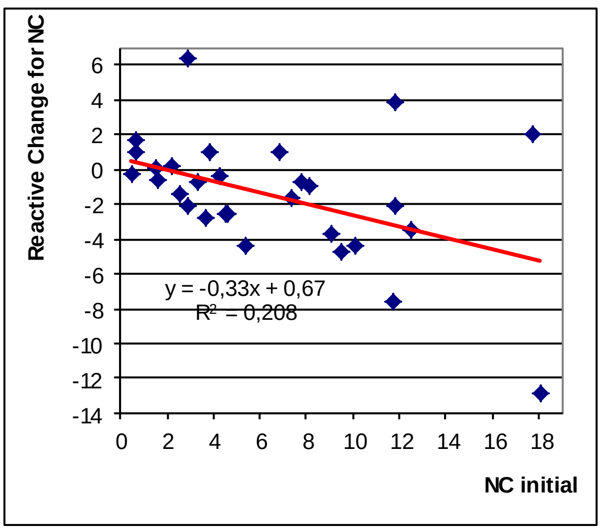
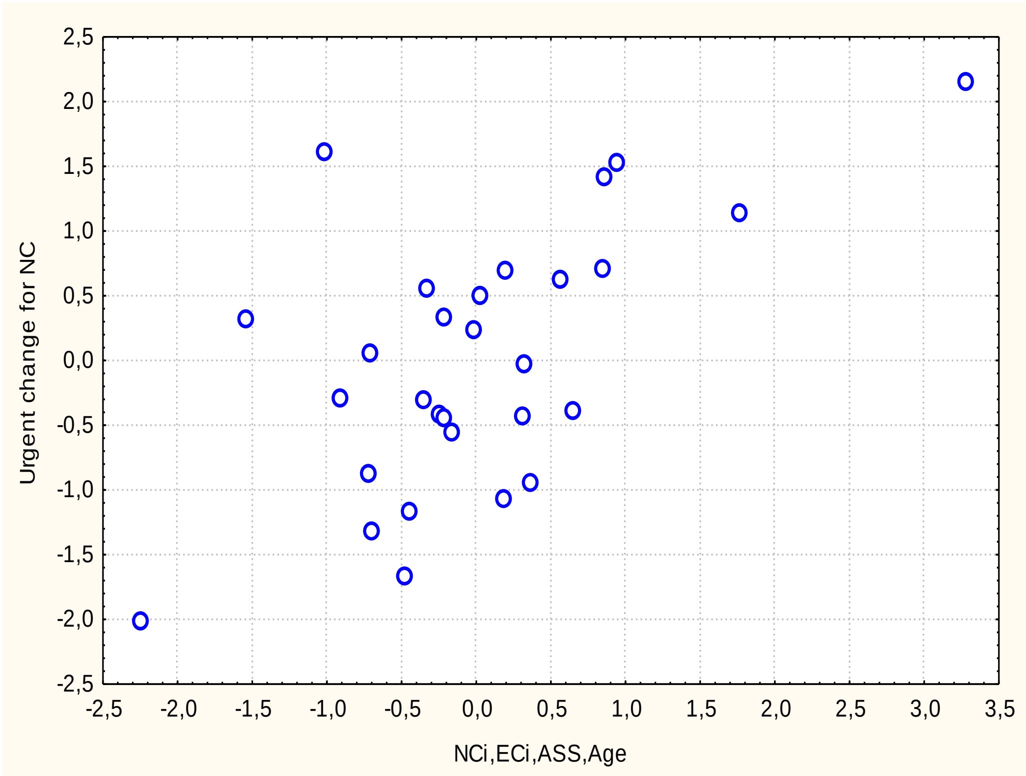


Fig. 8. Relationships between initial level of muscle tone neural component (axis X) and its change after one correction (axis Y)



dNCr = 2,22•ASS – 0,42•Age - 0,41•NCi - 0,29•ECi + 4,18
$R=0,60$; $R^2=0,37$; $F_{(4,2)}=6,45$; $\chi^2_{(4)}=11,4$; $p=0,023$

Fig. 9. Canonical correlation between age, spasticity, initial levels of muscle tone elastic and neural components (axis X) and change for neural component after one correction (axis Y)

At the same time, reaction muscle tone neural component to firtht correcting manipulation depend on initial level of muscle tone elastic component (r=-0,24), age (r=-0,44) and spasticity by Åshworth Scale (r=-0,21). These factors together determines change for neural component after one correction already on 37% (fig. 9).

In order to clarify the possibility of forecasting of character urgent effect by correction on neural component of muscle tone conducted discriminant analysis reported initial settings. Forward stepwise method identified 3 predictors (Table 7), knowledge of which condensed the two roots. Major root containing 70,6% predictive capabilities and represents reversely age of child. Minor canonical discriminant radical (the remaining 29,4% predictive capabilities) represents reversely MACS level and by straight modus initial level of elastic component.

Table 7. Results of discriminant analysis of parameters for forecasting of various urgent effects on neural component of muscle tone

Discriminant variables currently in the model	Parameters of Wilks' statistics			Coefficients for canonical variables				Means of predictors of different urgent effects		
	Λ	F	p	Raw		Structural		Decrease n=17	Neutral n=4	Increase n=8
				Root 1	Root 2	Root 1	Root 2			
Age	0,656	6,81	0,004	-0,42	0,24	**-0,67**	0,74	13,5±0,5	11,5±1,3	10,1±0,7
MACS level	0,514	4,94	0,002	-1,18	-1,07	-0,42	**-0,60**	2,24±0,16	1,25±0,25	2,25±0,31
Elastic component	0,426	4,26	0,002	0,39	0,33	0,05	**0,29**	1,52±0,37	2,04±0,78	1,20±0,63
Chi-square tests with successive roots removed	**Constant**			**7,04**	**-1,15**			**Means of canonical variables**		
	$r_1^*=0,66$; Wilks' $\Lambda=0,43$; $\chi^2_{(6)}=21,4$; $p=0,002$						Root 1	-0,66	+1,55	+0,62
	$r_2^*=0,49$; Wilks' $\Lambda=0,76$; $\chi^2_{(2)}=7,0$; $p=0,030$						Root 2	+0,15	+0,90	-0,77

The calculation of values of individual unstandardized canonical scores of roots by described earlier procedure allows vizualisation all the children on the plane of the two roots (fig. 10).

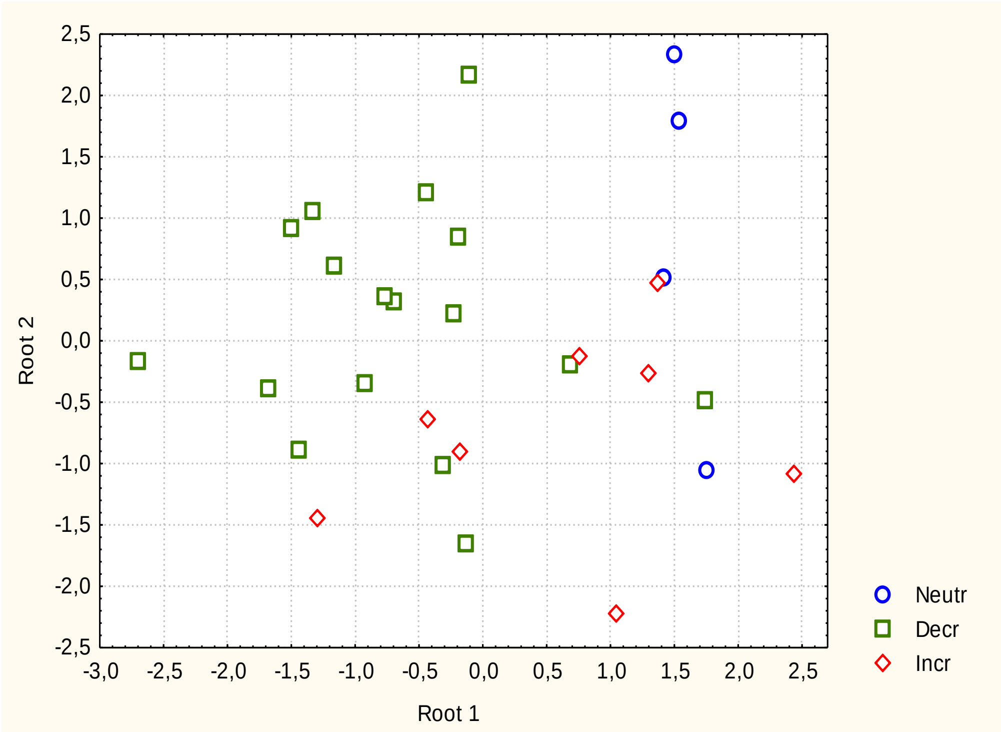


Fig. 10. Unstandardized canonical scores of roots of parameters-predictors for various urgent effects on neural component of muscle tone

Figure 10 illustrates that children with decrease of muscle tone neural component after one manual correction occupy of the axis Root 1 the leftmost zone (centroide: -0,66), that is, as a rule, are older than children of the other two clusters urgent reactions, which age not significantly different. The children with neutral urgent reactions along the axis Root 2 occupy the highest position (centroide: +0,90), reflecting them both maximal MACS level and minimal initial muscle tone elastic component level, whereas in the other two groups of children, these parameters do not differ significantly together. In general, on the plane two discriminant roots all three clusters clearly delineated. Squared Mahalanobis Distances (D^2_M) between clusters D and N average 6,08 (F=4,73; p=0,010), D and I: 2,80 (F=4,19; p=0,016), N and I: 4,08 (F=2,63; p=0,073).

The calculation of classification functions (table 8) allows correctly forecasting decrease muscle tone after one manipulation at 14 cases of 17 and neutral urgent effect at 3 cases of 4 while accuracy forecasting increase muscle tone present 50 % only (table 9).

Table 8. Classification functions for forecasting of various urgent effects on neural component of muscle tone

Variables-predictors	Decrease	Neutral	Increase
Age	3,484	2,734	2,726
MACS level	8,026	4,627	7,511
Elastic component	-2,068	-0,954	-1,864
Constant	-31,51	-19,62	-22,42

Table 9. Classification matrix forecasting of various urgent effects on neural component of muscle tone. Rows: Observed classifications; Columns: Predicted classifications

Urgent changes	Percent correct	Decrease p=0,586	Neutral p=0,138	Increase p=0,276
Decrease	82,4	14	0	3
Neutral	75,0	0	3	1
Increase	50,0	3	1	4
Total	72,4	17	4	8

It is more practical interest is the prediction level of muscle tone neural component after rehabilitation. We found that the relationship between levels of muscle tone after course of treatment and after one correction is on the border between moderate and significant (r=0,51) (fig. 11).

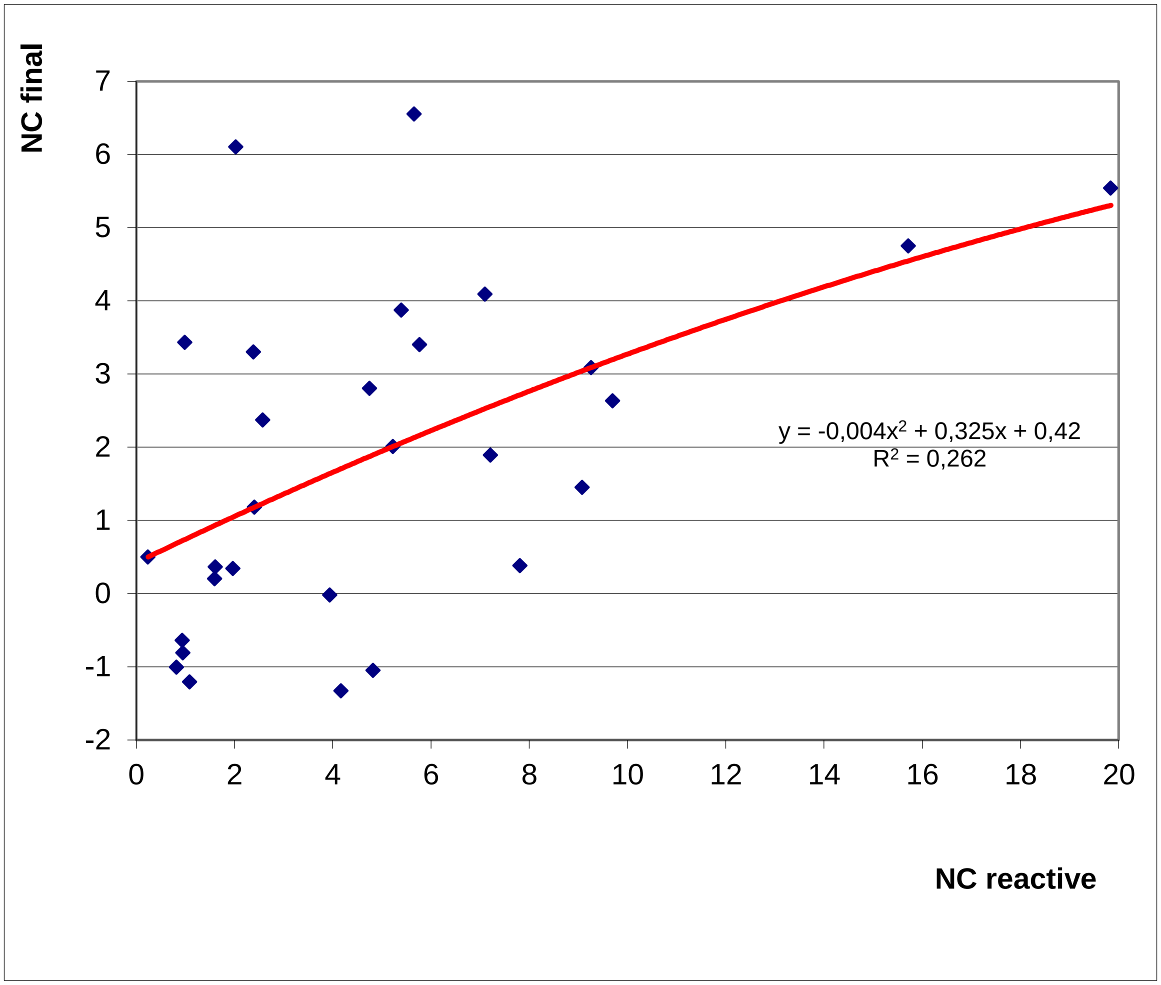
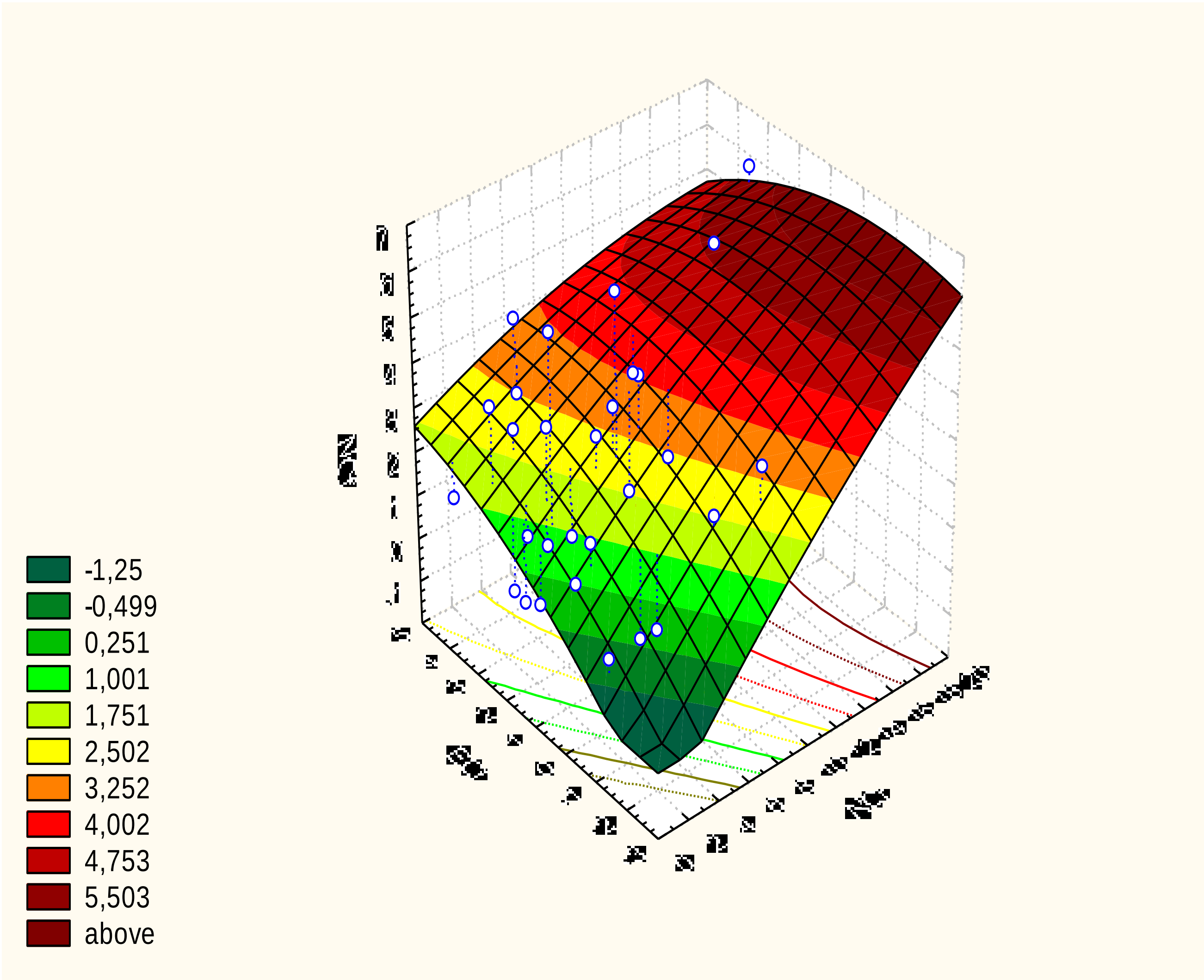


Fig. 11. Relationships between level of muscle tone neural component after one correction (axis X) and level after course of treatment (axis Y)

Taking into account relationship with initial level of muscle tone **elastic** component (r=0,28) strength determination final level of muscle tone neural component increases from 26% to 31% (fig. 12).

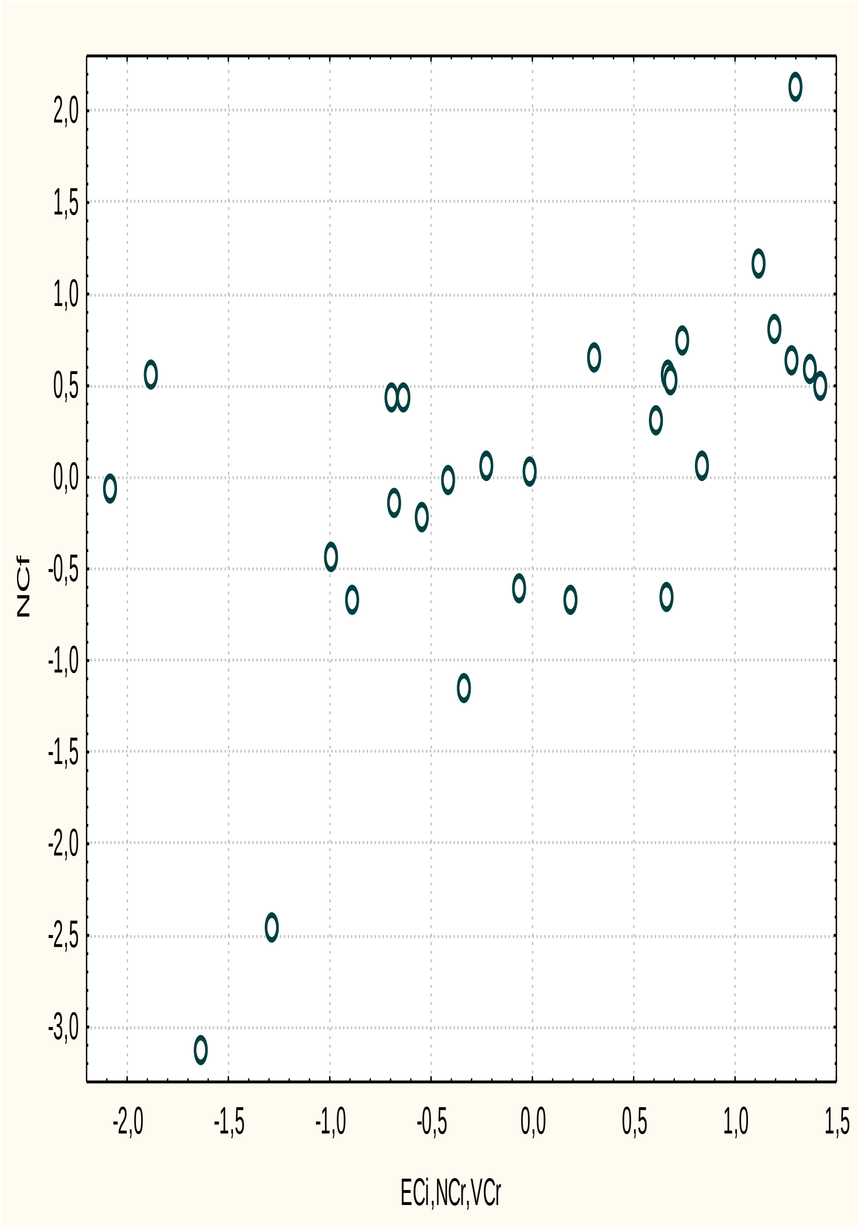


$NCf = 0,24 \cdot NCr + 0,325 \cdot ECi + 0,16$
$R=0,56; R^2=0,31; F_{(2,3)}=5,8; p=0,008$

Fig. 12. Relationship between initial muscle tone elastic component (ECi, ordinata), neural component after one correction (NCr, abscissa) and neural component after course rehabilitation (NCf, applicata)

While inclusing in multing regression equation **initial** level of muscle tone neural component despite more correlation (r=0,39) not increases strength determination: $R=0,51$; $R^2=0,26$; $F_{(2,3)}=4,6$; $p=0,02$.

Maximal strength determination (34%) **final** level of muscle tone neural component reached by additional account of muscle tone **viscous** component after one correction (r=0,25) (fig. 13).



$NCf = 0,242 \cdot NCr + 0,256 \cdot ECi + 0,19 \cdot VCr + 0,37$
$R=0,58$; $R^2=0,34$; $F_{(3,3)}=4,3$; $\chi^2_{(3)}=10,7$; $p=0,014$

Fig. 13. Canonical correlation between initial muscle tone elastic component (ECi), neural (NCr) and viscous (VCr) muscle tone components after one correction (axis X) and neural component after course rehabilitation (NCf) (axis Y)

Analysis of individual changes, visualized in fig. 14, shows that the change of muscle tone neural component after course of rehabilitation strongly (r=-0,88) depends on the initial level, that is determined by its on 78%. In connection with the consideration of level of muscle tone after first correction (r=-0,52) strength determination effectivity of rehabilitation contractility increases only to 81% (fig. 15).

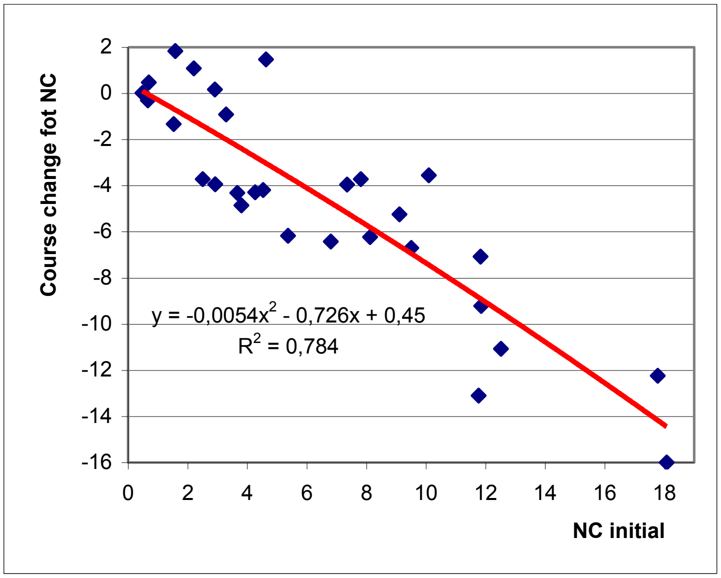
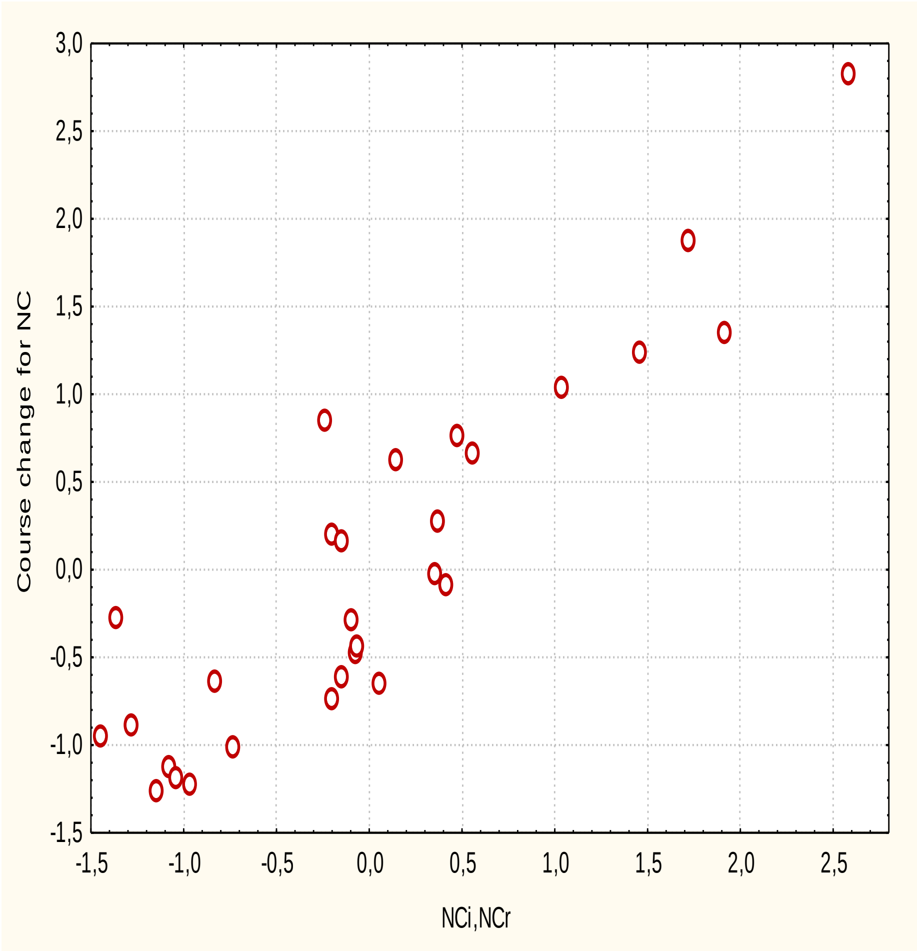


Fig. 14. Relationships between initial level of muscle tone neural component (axis X) and its change after course of treatment (axis Y)



dNCf = 0,241•NCr - 0,98•NCi + 0,53
R=0,90; R^2=0,81; $F_{(2,3)}$=56; $\chi^2_{(2)}$=43; p<10^{-6}

Fig. 15. Canonical correlation between initial and reactive levels of muscle tone neural component (axis X) and its change after course of treatment (axis Y)

Before clarify the possibility of forecasting of character course effect rehabilition on neural component of muscle tone we adduce means all initial parameters (table 10).

Table 10. Peculiarities of initial parameters (mean±SE) at children with various changes of muscle tone neural component after course of treatment by Kozyavkin's method

Change for neural component	Age	GMFCS level	MACS level	Åshworth scale spasticity	Muscle tone component		
					neural	elastic	viscous
Decrease n=23	12,7 0,5	2,22 0,18	2,26 0,16	1,30 0,10	7,62 1,00	1,53 0,31	-0,08 0,08
Neutral n=4	9,8 1,7	1,25 0,25	1,50 0,29	0,75 0,25	1,58 0,59	1,01 1,18	0,26 0,25
Increase n=2	13,0 0,0	2,00 0,00	1,50 0,50	1,00 0,00	3,11 1,52	2,11 0,74	-0,28 0,02
p_{1-2}	>0,1	<0,01	<0,05	=0,05	<0,001	>0,5	>0,2
p_{1-3}	>0,5	>0,5	>0,1	<0,01	=0,02	>0,5	<0,05
p_{2-3}	>0,1	<0,05	-	>0,5	>0,3	>0,5	>0,1

Next preliminary step is calculation individual factor scores for observed children (table 11).

Table 11. Factor analysis of initial parameters. Factor Scores for observed children.
Rotation: Equamax normalized. Extraction: Principal components

Pat/Effect	Factor1	Factor2	Factor3
1Incr	-,90	,47	-,17
2 Incr	-,41	,02	-,31
Mean	**-0,66**	**+0,25**	**-0,24**
3 Neu	-,43	-,14	-1,33
4 Neu	-1,55	-,93	1,23
5 Neu	-,30	-1,61	-,59
6 Neu	-1,36	1,78	1,15
Mean	**-0,91**	**-0,23**	**+0,12**
7 Decr	-,33	,28	-1,67
8 Decr	-,51	1,07	,49
9 Decr	-1,19	,16	-1,11
10 Decr	,05	-,29	,51
11 Decr	-1,19	,69	,84
12 Decr	,08	-,64	-,77
13 Decr	-,51	,01	-1,15
14 Decr	-,03	-,37	-,16
15 Decr	-,67	-,01	-,58
16 Decr	-,65	,44	,86
17 Decr	-,54	-,47	-,81
18 Decr	,18	-3,40	-,54
19 Decr	1,32	1,17	-1,69
20 Decr	,04	,92	,32
21 Decr	,82	-1,44	1,76
22 Decr	,01	,10	-,06
23 Decr	-,09	,38	1,13
24 Decr	1,77	-,43	1,20
25 Decr	1,08	,44	,84
26 Decr	1,13	-,43	1,25
27 Decr	2,76	,99	-1,37
28 Decr	-,06	,62	-,16
29 Decr	1,48	,61	,88
Mean	**+0,22**	**+0,02**	**0,00**

This allows visualization all observed children on informative field of three principal components (factors) (fig. 16). As you can see, taking into account **all the initial settings** significant differences between the three groups of children were not found.

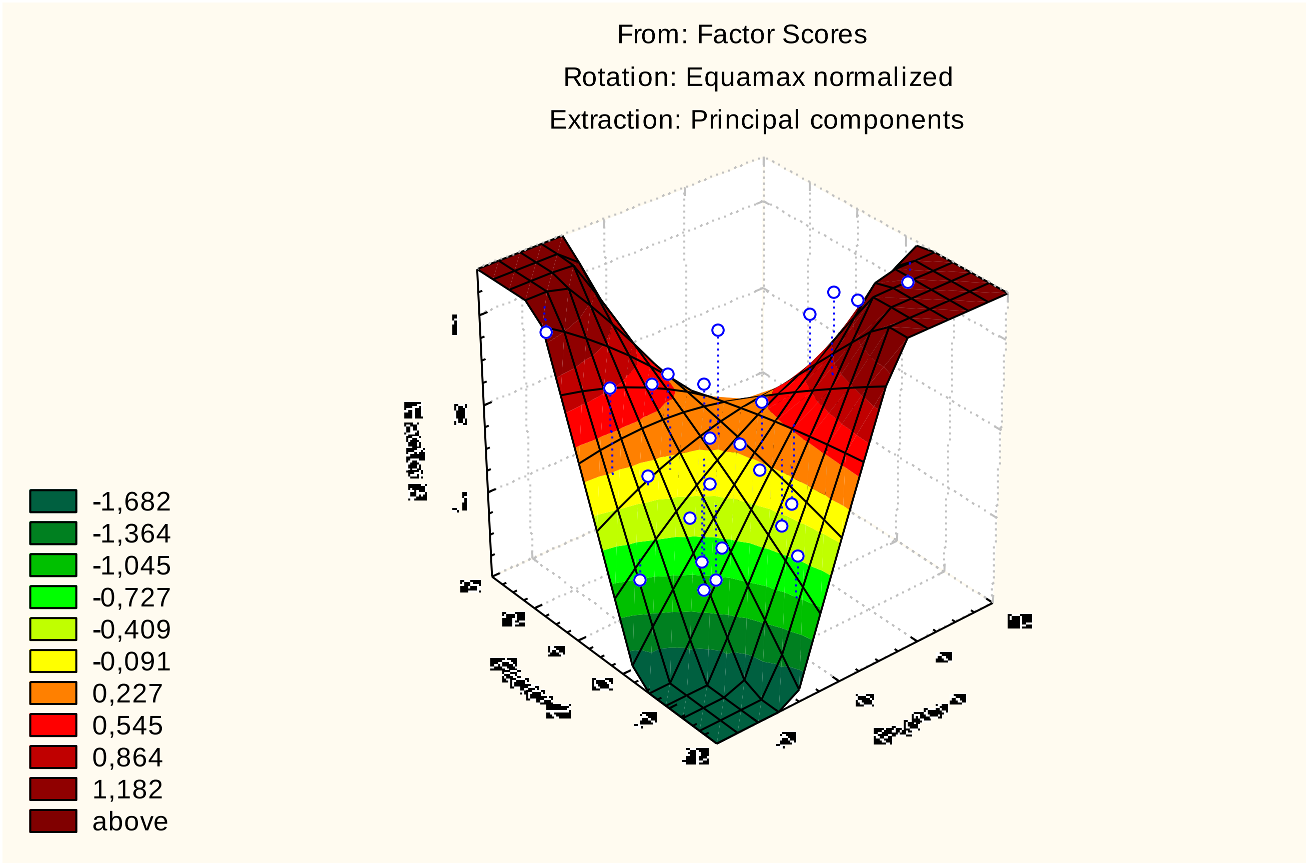


Fig. 16. 3D visualization of individual factor scores of initial parameters

At the final stage have been conducted discriminant analysis initial parameters. Forward stepwise method selected 5 **characteristic** parameters (table 12), knowledge of which condensed the two roots. Major canonical discriminant radical root containing 94,6% predictive capabilities while minor root containing 5,4% only. Root 1 represents reversely age of child, GMFCS level and initial level of muscle tone neural component which means at children with decrease of spasticity are more than at children with uncertain changes of spasticity. On the contrary initial level of muscle tone viscous component is less.

Table 12. Results of discriminant analysis of parameters for forecasting of various course effects on neural component of muscle tone

Discriminant variables currently in the model	Parameters of Wilks' statistics			Coefficients for canonical variables				Means of predictors of different effects of treatment		
	Λ	F	p	Raw		Structural		Decrease n=23	Neutral n=4	Increase n=2
				Root 1	Root 2	Root 1	Root 2			
Initial Neural Comp.	0,78	3,7	0,038	-0,09	-0,24	**-0,30**	-0,92	7,6±1,0	1,6±0,6	3,1±1,5
Age	0,42	4,3	0,001	-0,58	0,18	**-0,30**	*-0,04*	12,7±0,5	9,8±1,7	13,0±0,0
GMFCS level	0,29	3,8	0,001	-0,67	0,56	**-0,29**	-0,35	2,2±0,2	1,3±0,3	2,0±0,0
Initial Viscous Comp.	0,50	3,0	0,027	3,20	-0,65	**0,23**	-0,26	-0,1±0,08	0,3±0,25	-0,3±0,03
Reactive Elastic Com.	0,33	4,2	0,001	0,50	-0,22	*-0,02*	**-0,36**	2,1±0,3	1,8±1,1	1,3±0,1
Chi-square tests with successive roots removed	**Constant**			**8,36**	**-1,38**			**Means of canonical variables**		
	r_1^*=0,82; Wilks' Λ=0,29; $\chi^2_{(10)}$=29,9; p<10^{-3}					Root 1		-0,50	+3,41	-1,10
	r_2^*=0,36; Wilks' Λ=0,89; $\chi^2_{(4)}$=2,7; p=0,61					Root 2		-0,12	+0,09	+1,17

Variables currently not in the model
Df for all F-tests: 2,21

Variables	Wilks' Lambda	Partial Lambda	F to enter	p-level	Tole-rancy
MACS level	0,276	0,959	0,445	0,647	0,481
Åsworth Spasticity Scale	0,279	0,970	0,321	0,729	0,388
Reactive Neural Comp.	0,283	0,983	0,179	0,838	0,411
Initial Elastic Compon.	0,265	0,920	0,915	0,416	0,662
Reactive Viscous Comp.	0,263	0,914	0,984	0,390	0,686

From the combination of these parameters the initial state of children with neutral changes of spasticity significantly differ from children with both decrease and increase muscle tone neural component, as seen along the axis of the Root 1 (fig. 17). Along the root 2 axis, which represents reversely change for elastic component after first correction differ children with neutral and unfavourable changes of spasticity.

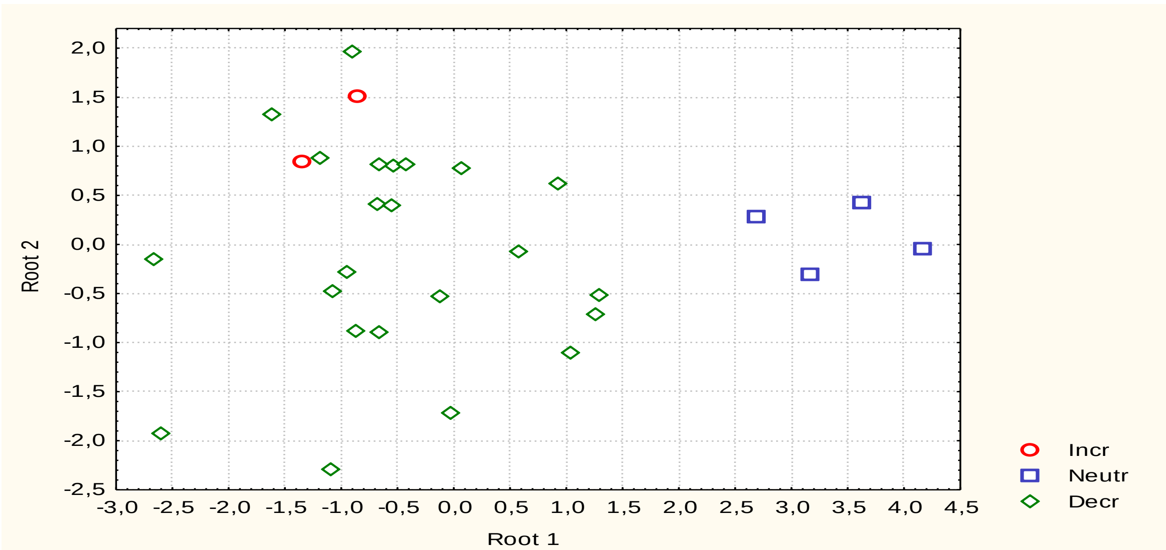


Fig. 17. Unstandardized canonical scores of roots of parameters-predictors for various treatment effects on neural component of muscle tone

Taking into account selected parameters-predictors D^2_M between clusters N and D average 17,1 (F=7,6; p<0,001), N and I: 24,0 (F=3,0; p=0,03), but between clusters D and I only 2,3 (F=0,37; p=0,87).

Table 13. Classification functions for forecasting of various course effects on muscle tone neural component

Discriminant variables-predictors	Decrease p=0,793	Neutral p=0,138	Increase p=0,069
Initial Neural Component	0,202	-0,202	-0,050
Initial Viscous Component	-25,36	-12,99	-28,12
Age	5,92	3,68	6,50
Reactive Elastic Component	-4,05	-2,14	-4,63
GMFCS level	8,27	5,67	9,42
Constant	-44,62	-19,68	-55,02

The calculation of classification functions (table 13) allows forecasting both favourable and neutral changes for spasticity after course of rehabilitation with 100% accuracy, while two cases increasing muscle tone neural component is not amenable to forecasting. Total accuracy forecasting present 93,1%.

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