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Предикторы эффективности медицинской реабилитации пациентов с детским церебральным параличом

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АННОТАЦИЯ

Введение. Одной из самых частых причин ограничений жизнедеятельности у детей является детский церебральный паралич (ДЦП). В медицинской реабилитации детей с ДЦП крайне важно иметь клинические инструменты, с помощью которых можно прогнозировать результат. Несмотря на то, что в настоящее время активно исследуются клинические и социально-экономические факторы, определяющие прогноз реабилитации и дальнейшей социальной адаптации пациентов с ДЦП, до сих пор не выявлены предикторы, позволяющие предсказать эффективность медицинский реабилитационных мероприятий.

Цель. Определить предикторы эффективности медицинской реабилитации у детей с ДЦП с использованием данных анамнеза, шкал и опросников.

Материалы и методы. В исследование включено 29 детей (средний возраст 5,4 ± 1,1 года) с различными формами ДЦП, которые на протяжении 12 мес. проходили медицинскую реабилитацию в условиях стационара и поликлиники. До и после реабилитационных мероприятий всем пациентам, помимо общесоматического и клинико-неврологического обследования, проводили тестирование с применением специализированных опросников и шкал, а также оценку с использованием краткого базового набора Международной классификации функционирования, ограничений жизнедеятельности и здоровья (МКФ) для детей и подростков с ДЦП. Распределение пациентов по группам производилась в зависимости от наличия улучшения с использованием разработанного нами критерия: снижение уровня определителя к компонентам классификации МКФ «функции», «активность и участие», как минимум, на 1 балл не менее чем в 3 доменах. Для изучения прогностической значимости данных анамнеза, шкал и опросников были применены различные одно- и мультивариантные модели логистической регрессии. Для определения пороговых уровней количественных показателей, оптимальных для прогноза того или иного исхода лечения, выполнялось построение ROC-кривой.

Результаты. Определено, что оценка по шкале GMFM-88 (шкала оценки глобальных моторных функций) более 82,1% до проведения реабилитационных мероприятий свидетельствует о положительном реабилитационном прогнозе. Домены МКФ b760 «контроль произвольных функций», d415 «поддержание положения тела» и d710 «базисные межличностные отношения» являются предикторами эффективности реабилитации у пациентов с ДЦП с уровнем определителя ≤ 1.

Заключение. Продемонстрировано, что более высокие показатели двигательных и координаторных функций, а также более высокий уровень межличностных взаимоотношений детей с ДЦП являются значимыми предикторами эффективности реабилитации.

Ключевые слова: *детский церебральный паралич; медицинская реабилитация; эффективность; предикторы; реабилитационный прогноз; международная классификация функционирования; МКФ*

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Predictors of the Effectiveness of Medical Rehabilitation of Patients with Cerebral Palsy

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ABSTRACT

INTRODUCTION: Cerebral palsy (CP) is one of the most common causes of disability in children. The use of clinical tools that will allow the prediction of results is necessary for the medical rehabilitation of children with CP. Although clinical and socio-economic factors that determine the prognosis of rehabilitation and further social adaptation of patients with CP are being actively investigated, predictors that help predict the effectiveness of medical rehabilitation measures are not yet identified.

AIM: To determine the predictors of the effectiveness of medical rehabilitation in children with CP using anamnesis, scales, and questionnaire data.

MATERIALS AND METHODS: The study involved 29 children (average age, 5.4 ± 1.1 years) with various forms of CP who underwent medical rehabilitation in inpatient and outpatient conditions within 12 months. Before and after rehabilitation courses, all patients, apart from general somatic-clinical and neurological examinations, underwent tests that use specialized questionnaires and scales and evaluation using the International Classification of Functioning, Disability and Health (ICF) Core Sets for children and adolescence with cerebral palsy. The patients were arranged into groups depending on the presence of improvement determined using the author-developed criterion: reduction of the determinant level relative to "function" and "activity and participation" components of ICF by a minimum of at least one point in three domains. Various uni- and multivariate logistic regression models were used to evaluate the prognostic significance of history, scales, and questionnaire data. Receiver operating characteristic curves were constructed to determine the threshold values of quantitative parameters optimal for predicting a certain treatment outcome.

RESULTS: The Gross Motor Function Measure 88 score of >82.1% before the rehabilitation measures indicated a positive rehabilitation prognosis. ICF domains b760 "control of voluntary movement functions", d415 "maintaining a body position", and d710 "basic interpersonal relations" are predictors of the effectiveness of rehabilitation in patients with a CP with determinant level ≤ 1.

CONCLUSION: The results demonstrated that higher parameters of motor and coordination functions and higher levels of interpersonal interactions of children with ICP are significant predictors of the effectiveness of rehabilitation.

Keywords: *infantile cerebral palsy; medical rehabilitation; efficiency; predictors; rehabilitation prognosis; international classification of functioning; ICF*

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ECO•VECTOR

LIST OF ABBREVIATIONS

VAS — Visual Analog Scale
CI — Confidence Interval
CP — Cerebral Palsy
ICF — International Classification of Functioning, Disability, and Health for Children and Youth with Cerebral Palsy
OR — Odds Ratio
GMFCS — Global Motor Function Classification System
GMFM-88 — Gross Motor Function Measure 88
MACS — Manual Ability Classification System

INTRODUCTION

Cerebral palsy (CP) is one of the most common causes of disability in children. The disease is defined as a group of permanent disorders in the development of movement and posture that result from a nonprogressive damage to the developing brain of the fetus or infant [1, 2]. The prevalence of CP in the Russian Federation corresponds to the global epidemiological situation and ranges, according to different data, from 2.0 to 3.0 cases per 1,000 newborns [3, 4]. In addition to motor disorders, the clinical presentation of CP includes problems with speech, mental retardation, epilepsy, and other abnormalities that limit the vital activity of a little patient [5, 6]. Thus, the rehabilitation of children with CP should include clinical tools that allow the prediction of results [7]. Although the clinical and socioeconomic factors determining the prognosis of rehabilitation and further social adaptation of patients with CP are being actively investigated [8, 9], predictors that help forecast the effectiveness of medical rehabilitation measures have not yet been identified.

This study **aimed** to determine predictors of the effectiveness of medical rehabilitation in children with CP using data of anamnesis, scales, and questionnaires.

MATERIALS AND METHODS

The prospective study was performed on the base of Clinic of Privolzhsk Research Medical University (PRMU) in 2017–2019 and was approved by the Local Ethic Committee of PRMU (Protocol No. 4 of March 29, 2017).

The study included patients with different forms of CP in accordance with the International Statistical Classification of Diseases and Related Health Problems of the 10th revision (spastic diplegia, G80.1; hemiplegia, G80.2; ataxic CP, G80.4; and mixed form, G80.8). Participants received detailed information about the study and its voluntary character. Informed consent was signed by the parents of children with CP and by a doctor-researcher.

Inclusion criteria: diagnosis of CP and age 4–8 years.

Exclusion criteria: alternative diagnosis associated with disorders in the movement and maintenance of posture, concomitant disease that according to the doctor-researcher might have affected the quality of patient's life, and a serious mental disorder (e.g., bipolar).

According to the international Global Motor Function Classification System (GMFCS), the level of motor disorders in patients with CP was 1.83 ± 0.50 points. The initial characteristics of the patients are given in Table 1.

Table 1. Initial Clinical and Demographic Data of the Patients (n = 29)

Characteristic	Result
Age, years	5.40 ± 1.05
Male gender, n (%)	20 (69%)
GMFCS, level	1.83 ± 0.5
Mother's age in the pregnancy period, years	27.4 ± 5.3
Father's age in the pregnancy period, years	31.5 ± 8.1
Sequential number of mother's pregnancy	1.97 [1; 2]
Term of delivery, weeks	34.5 ± 4.6
Apgar scale 1 min after birth, point	6.3 ± 2.0
Apgar scale 5 min after birth, point	7.4 ± 1.8
Newborn's weight, g	2547.6 ± 1012.1

The functioning profile and life limitations of all patients were evaluated before and 12 months after the rehabilitation measures based on the complaints and anamnestic data, results of general somatic and

clinical neurologic tests, and use of a short core set of the International Classification of Functioning, Disability, and Health (ICF) for children and youth with CP (Table 2). This short core set is used to evaluate the dynamics of a child's condition from age 0 to 18 years or for epidemiological research and includes 25 categories [10].

Table 2. Short Core Set of the International Classification of Functioning, Disability, and Health for Children and Adolescents with Cerebral Palsy [10]

Domain	Parameters
Organism Functions	
b117	Intelligent functions
b134	Sleep functions
b167	Mental functions of speech
b210	Vision functions
b280	Feeling of pain
b710	Joint mobility functions
b735	Muscle tone functions
b760	Control of voluntary motor functions
Organism Structures	
s110	Brain structure
Activity and Participation	
d415	Maintenance of body position
d440	Use of precise hand movements
d450	Walking
d460	Movement in different places
d530	Bladder and bowel functions
d550	Food intake
d710	Basic interpersonal relations
d760	Family relations
Environmental Factors	
e115	Products and technologies for personal everyday use
e120	Products and technologies for personal movement and transportation in-doors and out-of-doors
e125	Communication means and technologies
e150	Design, projecting, construction, and equipment of buildings for public use
e310	Family and close relatives
e320	Friends
e460	Public attitudes
e580	Healthcare services, administrative systems, and policy
Personal Factors*	
pf	Emotionality
pf	Activity in behavior and actions

Note: * Personal factor (Pf) component has not been assigned the categories of the International Classification of Functioning, Disability, and Health; thus, some examples representing PFs are given

To set the determinants, various graded assessment methods were used, including specialized scales and questionnaires:

- *Gross Motor Function Measure 88 (GMFM-88).*
- *Modified Ashworth Scale.*
- *Manual Ability Classification System (MACS) for children with CP.*
- *Visual analog scale (VAS).*

To identify anatomic and structural damages to the brain, all patients underwent magnetic resonance brain tomography [3]. Parameters for the assessment of values of different codes are given in Table 3.

Table 3. Parameters for the Assessment of the Domains of the International Classification of Functioning, Disability, and Health in Patients with Cerebral Palsy

Domain	Parameters	Assessment
b280	Feeling of pain	Visual analog scale
b710	Joint mobility functions	Ashworth scale
b735	Muscle tone functions	
b760	Control of voluntary functions	Gross Motor Function Measure 88
d415	Maintenance of body position	
d450	Walking	
d460	Movement in different places	
s110	Brain structure	Magnetic resonance brain tomography
d440	Use of precise wrist movements	Manual Ability Classification System for children with cerebral palsy

Based on the analysis of complaints and anamnestic data and on the results of physical and neuroimaging examinations of the patient, an assessment sheet was filled out where the categories of the ICF Core Sets for children and youth with CP were specified [10–12]. The assessment sheet provided a detailed description of the patient's functional profile including relevant contextual factors.

The results of medical rehabilitation were characterized using the criterion we have proposed. According to this criterion, an improvement was considered a reduction of the level of determinant to "functions" and "activity and participation" components of ICF classification of at least 1 point in at least in three domains. The sensitivity and specificity of this criterion, according to results of a previous study, were 89% and 91%, respectively [7].

Rehabilitation measures were conducted throughout 1 year in the inpatient, outpatient, and home conditions. In a hospital setting, rehabilitation included mechanotherapy, therapeutic exercise, massage, physiotherapy, reflexology, and pharmacotherapy as needed. Courses (14 days) of inpatient rehabilitation were conducted two times a year. The outpatient rehabilitation supposed 2–3 massage courses of 10-day duration and botulinum therapy. In home conditions, rehabilitation included doing daily physical exercises recommended by the doctor. In addition, consultations were held for the patient's parents to identify "barrier" environmental factors and modify them into "facilitating" factors, according to the ICF terminology.

Statistical processing of the results was conducted using MedCalc Statistical Software and Microsoft Office Excel (2010). The following statistical methods were used: the Shapiro–Wilk test was used to check the character of the distribution of quantitative parameters. The selected parameters were as follows: Me, median; Q1, lower quartile; Q3, upper quartile; mean, arithmetic mean; SD, standard deviation; n, volume of the analyzed group; and p, significance value of the differences. Statistical comparison of the mean values in the group was performed using parametric and nonparametric statistical methods, namely, Student paired t-test and Wilcoxon test, respectively, for related samples, and Student t-test and Mann–Whitney test, respectively, for unrelated samples. To test the hypothesis of the dependence of qualitative and order characteristics, Pearson $\chi 2$ criterion for contingency tables was used. In the case of risk of bias of the results obtained using Pearson $\chi 2$ criterion for contingency tables, Fisher's exact test was used to test the null hypothesis by pairwise comparison of data of the analyzed groups in four-field tables, taking into account Bonferroni correction for multiple comparisons. Parameters with significant difference in the subgroups according to the single-factor analysis were introduced into the logistic regression procedure. To assess the predictive value of a predictor, the sensitivity, specificity, and predictive values of positive and negative results were calculated. To determine the threshold levels of quantitative parameters optimal for predicting a particular outcome of treatment, the receive operating characteristic curve was constructed, demonstrating the dependence of the number of true-positive cases on the number of false-negative cases of classification based on predictors. The threshold value of the quantitative predictor (e.g., result on the GMFM-88 scale) was the one for which the area under the receiver operating characteristic (ROC) curve was the largest, as such a curve corresponds to the optimal combination of sensitivity and specificity of the predictor. The critical value of the significance level was assumed to be 5% ($p \leq 0.05$).

RESULTS

Within 12 months after the rehabilitation procedures, an improvement was achieved in 18 patients (62%) with

CP (group 1), and 11 patients (38%) had no improvement (group 2). In group 1, there was a decrease in the intensity of pain syndrome, increased joint mobility and control of voluntary movements, and improved maintenance of body position, walking, and precise hand movements. There was also a decrease in spasticity in barriers restricting life activity and an improvement in the quality of life. An improvement in gross motor functions on the GMFM-88 scale ($p<0.0001$), a decrease in spasticity level on the Ashworth scale ($p = 0.0005$), an improvement in manual abilities on the MACS scale ($p = 0.0078$), and a decrease in pain syndrome on VAS ($p = 0.0001$) were found. In group 2, no significant change in clinical manifestations and no significant change in the parameters on the above scales were noted. The level of motor functions on the GMFCS scale remained the same in patients in both groups.

In Table 4, the number of patients in samples with different extent of severity of disorders in different ICF domains before and after rehabilitation measures is given.

Table 4. Number of Patients with Cerebral Palsy in Groups with Different Degrees of Severity of Disorders Before and After Rehabilitation Measures

Domain/Parameter	Extent of Severity of Disorders															
	1				2				3				4			
	Mild (5%–24%)				Moderate (25%–49%)				Severe (50%–95%)				Absolute (96%–100%)			
	Group with improvement, n		Group with no improvement, n		Group with improvement, n		Group with no improvement, n		Group with improvement, n		Group with no improvement, n		Group with improvement, n		Group with no improvement, n	
	before	after	before	after	before	after	before	after	before	after	before	after	before	after	before	after
b117 — intelligent functions	3	3	4	4	–	–	2	2	–	–	–	–	–	–	–	–
b134 — sleep functions	10	–	4	5	–	–	1	–	–	–	–	–	–	–	–	–
b167 — mental functions of speech	2	2	3	3	–	–	–	–	–	–	–	–	–	–	–	–
b210 — vision functions	2	2	4	4	–	–	–	–	–	–	–	–	–	–	–	–
b280 — feeling of pain	12	–	7	9	3	–	2	–	–	–	1	–	–	–	–	–
b710 — joint mobility functions	6	16	–	–	10	–	2	2	–	–	9	9	–	–	–	–
b735 — muscle tone functions	6	16	–	–	10	–	2	2	–	–	9	9	–	–	–	–
b760 — control of voluntary motor functions	13	9	2	2	5	–	4	6	–	–	5	3	–	–	–	–
d415 — maintenance of body position	11	2	1	3	3	–	8	7	–	–	2	1	–	–	–	–
d440 — use of precise hand movements	6	14	4	2	8	–	1	1	–	–	5	5	–	–	–	–
d450 — walking	8	6	–	3	9	–	5	4	–	–	5	3	–	–	1	1
d460 — movement in different places	7	11	–	2	10	–	4	4	–	–	7	5	–	–	–	–
d530 — bladder and bowel functions	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
d550 — food intake	5	–	5	5	–	–	–	–	–	–	–	–	–	–	–	–
d710 — basic interpersonal relations	11	2	6	7	–	–	4	3	–	–	–	–	–	–	–	–
d760 — family relations	8	2	7	7	–	–	1	1	–	–	–	–	–	–	–	–

Patients with improvement showed significant reduction of the determinant score (according to the criterion we have proposed [7]) in domain b134 “sleep functions” ($p = 0.0020$), b280 “feeling of pain” ($p = 0.0001$), b710 “joint mobility functions” ($p = 0.0020$), b735 “muscle tone functions” ($p = 0.0020$), b760 “control of voluntary functions” ($p = 0.0001$), d415 “maintenance of body position” ($p = 0.0002$), d440 “use of precise hand movements” ($p = 0.0078$), d450 “walking” ($p < 0.0001$), d460 “movement in different places” ($p < 0.0001$), d710 “basic interpersonal relations” ($p = 0.0039$), d760 “family relations” ($p = 0.0313$). In patients without improvement, no reliable changes in the determinant levels were observed in any domain.

As possible predictors of the effectiveness of rehabilitation, the results of the assessment on the Ashworth scale, MACS, VAS, and GMFM-88 were considered. Comparison of groups of patients with and

without improvement showed that the groups before rehabilitation measures showed significant differences on the GMFCS scale (p = 0.0083), GMFM-88 (p = 0.001), Ashworth scale (p = 0.0001), and VAS (p = 0.0357, Table 5).

Table 5. Parameters of Questionnaires and Scales in Patients with Cerebral Palsy before Rehabilitation Depending on the Results of Subsequent Rehabilitation

Scale/Questionnaire	Mean Value of Parameter		p
	Patients with Improvement, n = 18	Patients without Improvement, n = 11	
GMFCS	2 [1; 2]	2 [2; 2]	***0.0083****
GMFM-88	88.8 ± 3.5	71.4 ± 11.3	***0.001****
Ashworth scale	3 [1; 3]	4 [4; 4]	***0.0001****
MACS	1 [1; 2]	2 [1; 3]	0.1056**
VAS	2 [1; 2]	2 [2; 5]	***0.0357****

Note: * Student's t-test, ** Mann–Whitney test

Further, the levels of determinants of ICF domains characterizing pain syndrome, motor and coordination function disorders, and interpersonal relations and relations of the child were compared between the groups. Analysis of unrelated samples showed that before rehabilitation measures, patients with improvement have on average more optimal parameters in the following ICF domains: b710 "joint mobility functions" (p < 0.0001), b735 "muscle tone functions" (p < 0.0001), b760 "control of voluntary functions" (p = 0.0014), d415 "maintaining body position" (p = 0.0002), d450 "walking" (p = 0.0001), d460 "movement in different places" (p = 0.0002) and d710 "basic interpersonal relations" (p = 0.0105, Table 6).

Table 6. Level of Determinants of Domains of the International Classification of Functioning, Disability, and Health in Patients with Cerebral Palsy before Rehabilitation, Depending on the Results of Subsequent Rehabilitation

Domain	Patients with Improvement n = 18	Patients without Improvement, n = 11	p*
b280	1 [1; 1]	1 [1; 2]	0.2258
b710	2 [1; 2]	3 [3; 3]	***< 0.0001***
b735	2 [1; 2]	3 [3; 3]	***< 0.0001***
b760	1 [1; 2]	2 [2; 3]	***0.0014***
d415	1 [1; 1]	2 [2; 2]	***0.0002***
d440	1 [1; 2]	2 [1; 3]	0.1056
d450	1,5 [1; 2]	3 [2; 3]	***0.0001***
d460	2 [1; 2]	3 [2; 3]	***0.0002***
d710	1 [0; 1]	1 [1; 2]	***0.0105***
d760	0 [0; 1]	1 [0,25; 1]	0.1117

Note: * Mann–Whitney test

Among the anamnestic data, the following parameters were considered possible predictors of the effectiveness of rehabilitation: mother's and father's age at the time of pregnancy, sequential number of the mother's pregnancy, term of delivery, newborn's weight, child's gender, Apgar scale score 1 and 5 min after birth, and child's age at the time he was diagnosed with CP. *None of the anamnestic parameters demonstrated a significant difference in the groups of patients with and without improvement and thus cannot be introduced in the binary logistic regression procedure for the determination of the predictive capacity.*

The parameters of scales and ICF domains that showed significant differences in groups of patients with and without improvement were introduced in the binary logistic regression procedure to determine predictors of rehabilitation effectiveness with the highest predictive value. Initially, univariate regression analysis was conducted to evaluate the influence of each independent variable on the result. The univariate analysis showed

that the more significant predictors of the effectiveness of rehabilitation are GMFM-88 score (p = 0.0127) and the level of determinant in the following ICF domains (Table 7):

- b760 "control of voluntary functions" (p = 0.0050)
- d415 "maintenance of body position" (p = 0.0040)
- d710 "basic interpersonal relations" (p = 0.0266)

Each model is recognized as adequately describing the influence of predictors on the rehabilitation outcome (improvement or its absence). This is evidenced by a high significance level of the $\chi 2$ parameter, which tests the hypothesis of a zero significance of the evaluation of the parameter for predictor (i.e., the hypothesis that the predictor influences the outcome of rehabilitation).

Table 7. Predictors of Effectiveness of Rehabilitation in Patients with Cerebral Palsy: Results of the Univariate Logistic Regression

Predictor	Wald $\chi 2$	p	OR	95% CI
Global Motor Function Classification System	0.000005340	0.9982	5.27 x 1010	–
Gross Motor Function Measure 88	*6.2169*	*0.0127*	*1.5280*	*1.0949–2.1323*
Ashworth scale	0.000007970	0.9977	1.24 x 1010	–
Visual analog scale	1.4183	0.2337	0.7256	0.4280–1.2301
b760 "control of voluntary motor functions"	*7.8974*	*0.0050*	*0.1029*	*0.0211–0.5026*
d415 "maintenance of body position"	*8.2805*	*0.0040*	*0.0316*	*0.0030–0.3324*
d710 "basic interpersonal relations"	*4.9145*	*0.0266*	*0.0975*	*0.0125–0.7636*

Note: OR, odds ratio; CI, confidence interval

When performing multivariate logistic regression with various models that included several variables (GMFM-88, b760, d415, and d710), no significant predictors were identified. No model has shown that a combination of several variables can be a predictor of a positive outcome of rehabilitation. Thus, each factor can be used as a predictor of the effectiveness of rehabilitation only separately.

The sensitivity and specificity of the threshold value of all predictors of rehabilitation effectiveness were analyzed by constructing a ROC curve. The area under the ROC curve for the GMFM-88 scale was 0.937 (p < 0.001), which corresponds to a high quality of the prognosis (Figure 1). Patients with the GMFM-88 score before rehabilitation procedures > 82.1% have a positive prognosis for rehabilitation. IFC domains b760 "control of voluntary functions" (area below the ROC curve, 0.833; p < 0.001), d415 "maintenance of body position" (area under the ROC curve, 0.896; p < 0.001), and d710 "basic interpersonal relations" (area under the ROC curve, 0.760; p = 0.001) are predictors of the effectiveness of rehabilitation in patients with CP with the determinant level ≤1 (Figues 2–4).

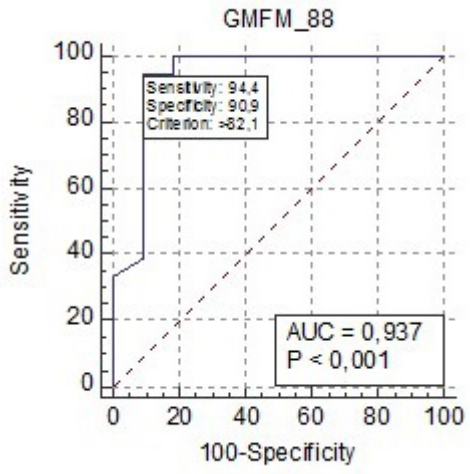

Fig. 1. Receiver operating characteristics curve for the evaluation on the Gross Motor Function Measure 88 scale.

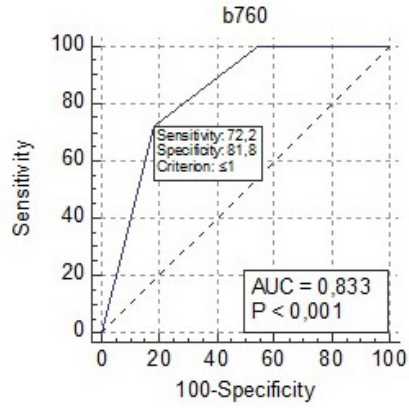

Fig. 2. Receiver operating characteristics curve for the evaluation by domain b760 "control of voluntary movement functions".

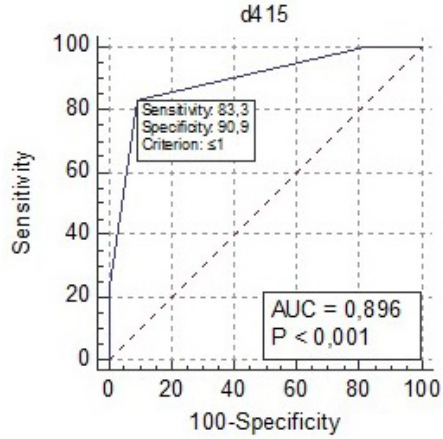

Fig. 3. Receiver operating characteristics curve for the evaluation by domain d415 "maintaining body position".

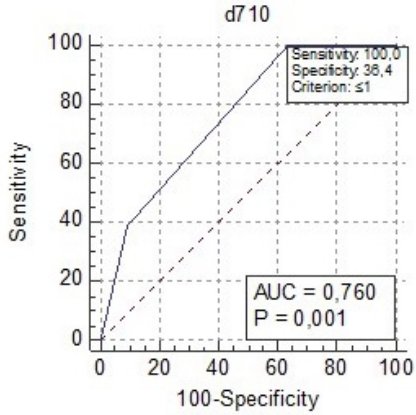

Fig. 4. Receiver operating characteristics curve for the evaluation by domain d710 "basic interpersonal relations".

DISCUSSION

In the given work, clinical and neurologic examination results were evaluated using specialized questionnaires, scales, and ICF core set for children and adolescents with CP, which can predict the effectiveness of medical rehabilitation of children with CP. The significant predictors of the effectiveness of medical rehabilitation

of children with CP were GMFM-88 score >82.1% and determinant level ≤1 in the following ICF domains: b760 "control of voluntary functions," d415 "maintenance of body position," and d710 "basic interpersonal relations".

GMFM-88 is used for quantifying gross motor function [13]. This scale was proposed by Dianne Russell (CanChild Center for Childhood Disability Research, McMaster University, Institute of Applied Medical Sciences). GMFM-88 was designed to evaluate the change in the gross motor function over time in children with cortical paralysis. GMFM-88 is characterized by grouping the tasks according to the initial position when performing them: lying on hands and knees, sitting, standing, walking, running, and jumping. Complete GMFM-88 evaluation takes approximately 40 min. For most positions, there are special descriptions for each score. Thus, it is important to use the descriptions given in the manual for GMFM-88 [3].

ICF is used in both scientific research and clinical practice [7,10]. These aspects are especially important for such a nosological form as CP, as currently numerous treatment methods for this pathology are proposed without sufficient proof of their effectiveness [11]. The efforts of parents, children, and medical personnel are directed to the selection of effective and safe therapeutic interventions [14], and ICF is the tool that helps identify the actual problems of a child with CP and determine aims and objectives of rehabilitation, plan and control treatment, and measure the achieved results [7,14,15]. However, certain problems impede the practical application of ICF, such as the bulkiness of this classification (it includes >1,600 categories) [12,16]. This problem is solved by the use of the condensed classification version with a set of informative signs for a particular disease (so-called core sets or basic sets) [14]. ICF core sets are developed by a group of international experts of the World Health Organization and present a list of categories used as the international standard for the description of functions of particular nosological forms [17]. Consensus on the ICF core sets in the application to CP was achieved not so long ago, and the results of the work of the expert group were published in 2015 [10]. A short core set including 25 categories is convenient either for the evaluation of the dynamics of a child's condition from 0 to 18 years or for epidemiological research [10,11]. Detailed instruction on the selection and use of the core set are available in the open press [10].

GMFM-88 and the ICF basic set for children and adolescents are actively used in planning and implementation of medical rehabilitation in patients with CP [7,10,18]. These clinical tools are very well known to the doctors, scientists, and other specialists involved in the rehabilitation of children with CP. Knowledge of the threshold values of GMFM-88 and short ICF core set for children and adolescents with CP, which can predict the effectiveness of rehabilitation measures, plays an important role in planning medical rehabilitation and determination of rehabilitation potential of children with CP.

Despite the results obtained, the determination of the predictors of the effectiveness of medical rehabilitation of children with CP remains relevant [19]. Studies involving numerous patients and longer follow-up period are required. In the future, the identification of predictors of the effectiveness of medical rehabilitation will allow to more correctly determine the rehabilitation potential of a patient with CP and select the necessary complex of rehabilitation measures.

CONCLUSION

This study revealed the predictors of rehabilitation effectiveness and their threshold values, which can help in the development of medical rehabilitation programs for patients with CP. Higher parameters of motor and coordination functions and a higher level of interpersonal relationships of patients with CP are significant predictors of the effectiveness of rehabilitation. The results indicate the need to use the ICF and quantitative assessment of the GMFM-88 when planning rehabilitation activities for patients with CP.

ADDITIONAL INFORMATION

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СПИСОК ИСТОЧНИКОВ

1. Rosenbaum P., Paneth N., Leviton A., et al. A report: the definition and classification of cerebral palsy April 2006 // Developmental Medicine & Child Neurology. 2007. Vol. 109. P. 8–14.
2. Castelli E., Fazzi E., SIMFER-SINPIA Intersociety Commission. Recommendations for the rehabilitation of children with cerebral palsy // European Journal of Physical and Rehabilitation Medicine. 2016. Vol. 52, № 5. P. 691–703.
3. Семёнова Е.В., Клочкова Е.В., Коршикова-Морозова А.Е., и др. Реабилитация детей с ДЦП: обзор современных подходов в помощь реабилитационным центрам. М.: Лепта книга; 2018.
4. Wimalasundera N., Stevenson V.L. Cerebral palsy // Practical Neurology. 2016. Vol. 16, № 3. P.184–194. doi: 10.1136/practneurol-2015-001184
5. Клинические рекомендации. Детский церебральный паралич у детей. М.: Союз педиатров России; 2016. Доступно по: https://nasdr.ru/wp-content/uploads/2019/06/kr_dcp.pdf.
6. Verschuren O., Peterson M.D., Balemans A.C.J., et al. Exercise and physical activity recommendations for people with cerebral palsy // Developmental Medicine & Child Neurology. 2016. Vol. 58, № 8. P. 798–808. doi: 10.1111/dmcn.13053
7. Шейко Г.Е., Белова А.Н., Кузнецов А.Н., и др. Применение Международной классификации функционирования, ограничения жизнедеятельности и здоровья детей и подростков в оценке реабилитационных мероприятий у пациентов с детским церебральным параличом // Вестник восстановительной медицины. 2020. Т. 99, № 5. С. 38–45. doi: 10.38025/2078-1962-2020-99-5-38-45
8. Andrade P.M.O., Haase V.G., Oliveira–Ferreira F. An ICF-based approach for cerebral palsy from a biopsychosocial perspective // Developmental Neurorehabilitation. 2012. Vol. 15, № 6. P. 391–400. doi: 10.3109/17518423.2012.700650
9. Almasri N.A., O'Neil M.E., Palisano R.J. Predictors of needs for families of children with cerebral palsy // Disability and Rehabilitation. 2014. Vol. 36, № 3. P. 210–219. doi: 10.3109/09638288.2013.783123
10. Schiariti V., Selb M., Cieza A., et al. International Classification of Functioning, Disability and Health Core Sets for children and youth with cerebral palsy: a consensus meeting // Developmental Medicine & Child Neurology. 2015. Vol. 57, № 2. P. 149–158. doi: 10.1111/dmcn.12551
11. Schiariti V., Sauve K., Tatla S. Which Measure Should I Use?: Content Analysis Using the ICF Core Sets for Children and Youth with Cerebral Palsy // Paediatrics & Child Health. 2015. Vol. 20, № 5. P. e41–e42. doi: 10.1093/pch/20.5.e41
12. Белова А.Н., Шейко Г.Е., Шаклунова Н.В., и др. Медицинская реабилитация при детском церебральном параличе: применение Международной классификации функционирования, ограничений жизнедеятельности и здоровья детей и подростков // Вестник восстановительной медицины. 2019. № 1. С. 2–9.
13. Russell D.J., Rosenbaum P.L., Avery L.M., et al. Gross Motor Function Measure (GMFM-66 & GMFM-88): User's Manual. London: London: Mac Keith, distributed by Cambridge University Press; 2002.
14. Schiariti V., Mahdi S., Bölte S. International Classification of Functioning, Disability and Health Core Sets for cerebral palsy, autism spectrum disorder, and attention-deficit-hyperactivity disorder // Developmental Medicine & Child Neurology. 2018. Vol. 60, № 9. P. 933–941. doi: 10.1111/dmcn.13922
15. Jeevanantham D. Application of the International Classification of Functioning, Disability and Health — Children and Youth in Children With Cerebral Palsy // Indian Pediatrics. 2016. Vol. 53, № 9. P. 805–810. doi: 10.1007/s13312-016-0935-8
16. Шошмин А.В., Пономаренко Г.Н., Бесстрашнова Я.К., и др. Применение международной классификации функционирования, ограничений жизнедеятельности и здоровья для оценки эффективности реабилитации: методология, практика, результаты // Вопросы курортологии, физиотерапии и лечебной физической культуры. 2016. Т. 93, № 6, С. 12-20. doi: 10.17116/kurort2016612-20
17. Weigl M., Cieza A., Andersen C., et al. Identification of relevant ICF categories in patients with chronic health conditions: a Delphi exercise // Journal of Rehabilitation Medicine. 2004. № 44 Suppl. P. 12–21. doi: 10.1080/16501960410015443
18. Yun Y.N., Choi G.E., Lim H. Assessment Using the ICF-core set for Children and Youth with Cerebral Palsy: A Single Case Study // The Journal of Korean Physical Therapy. 2019. Vol. 31, № 2. P.103-110. doi: 10.18857/JKPT.2019.31.2.103
19. Van Gorp M., Roebroeck M.E., van Eck M., et al. Childhood factors predict participation of young adults with cerebral palsy in domestic life and interpersonal relationships: a prospective cohort study // Disability and Rehabilitation. 2020. Vol. 42, № 22. P. 3162-3171. doi: 10.1080/09638288.2019.1585971

REFERENCES

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy April 2006. *Developmental Medicine & Child* Neurology. 2007;109:8–14.
2. Castelli E, Fazzi E, SIMFER-SINPIA Intersociety Commission. Recommendations for the rehabilitation of children with cerebral palsy. *European Journal of Physical and Rehabilitation Medicine.* 2016; 52(5):691–703.
3. Semyonova EV, Klochkova EV, Korshikova-Morozova AE, et al. *Reabilitatsiya detey s DTsP: obzor sovremennykh podkhodov v pomoshch' reabilitatsionnym tsentram.* Moscow: Lepta Kniga; 2018. (In Russ).
4. Wimalasundera N, Stevenson VL. Cerebral palsy. *Practical Neurology.* 2016;16(3):184–94. doi: 10.1136/practneurol-2015-001184
5. *Klinicheskiye rekomendatsii. Detskiy tserebral'nyy paralich u detey.* Moscow: Union of Pediatricians of Russia; 2016. (In Russ). https://nasdr.ru/wp-content/uploads/2019/06/kr_dcp.pdf.
6. Verschuren O, Peterson MD, Balemans ACJ, et al. Exercise and physical activity recommendations for people with cerebral palsy. *Developmental Medicine & Child Neurology.* 2016;58(8):798–808. doi: 10.1111/dmcn.13053
7. Sheiko GE, Belova AN, Kuznetsov AN, et al. Application of the International Classification of Functioning, Disability and Health (Children and Youth Version) in the Evaluation of Rehabilitation Measures of Patients with Cerebral Palsy. *Bulletin of Rehabilitation Medicine.* 2020;99(5):38-45. (In Russ). doi: 10.38025/2078-1962-2020-99-5-38-45
8. Andrade PMO, Haase VG, Oliveira–Ferreira F. An ICF-based approach for cerebral palsy from a biopsychosocial perspective. *Developmental Neurorehabilitation.* 2012;15(6):391–400. doi: 10.3109/17518423.2012.700650
9. Almasri NA, O'Neil ME, Palisano RJ. Predictors of needs for families of children with cerebral palsy. *Disability and Rehabilitation.* 2014;36(3):210–9. doi: 10.3109/09638288.2013.783123
10. Schiariti V, Selb M, Cieza A, et al. International Classification of Functioning, Disability and Health Core Sets for children and youth with

cerebral palsy: A consensus meeting. *Developmental Medicine & Child Neurology.* 2015;57(2):149–58. doi: 10.1111/dmcn.12551
11. Schiariti V, Sauve K, Tatla S. Which Measure Should I Use?: Content Analysis Using the ICF Core Sets for Children and Youth with Cerebral Palsy. *Paediatrics & Child Health.* 2015;20(5):e41-2. doi: 10.1093/pch/20.5.e41
12. Belova AN, Sheiko GE, Shaklunova NV, et al. Medical Rehabilitation of Children with Cerebral Palsy: Application of the International Classification of Functioning, Disability and Health (Children & Youth Version). *Bulletin of Rehabilitation Medicine.* 2019;(1):2-9. (In Russ).
13. Russell DJ, Rosenbaum PL, Avery LM, et al. *Gross Motor Function Measure (GMFM-66 & GMFM-88): User's Manual.* London : Mac Keith, distributed by Cambridge University Press; 2002.
14. Schiariti V, Mahdi S, Bölte S. International Classification of Functioning, Disability and Health Core Sets for cerebral palsy, autism spectrum disorder, and attention-deficit-hyperactivity disorder. *Developmental Medicine & Child Neurology.* 2018;60(9):933-41. doi: 10.1111/dmcn.13922
15. Jeevanantham D. Application of the International Classification of Functioning, Disability and Health — Children and Youth in Children With Cerebral Palsy. *Indian Pediatrics.* 2016;53(9):805–10. doi: 10.1007/s13312-016-0935-8
16. Shoshmin AV, Ponomarenko GN, Besstrashnova YaK, et al. The application of the International Classification of functioning, disability and health for the evaluation of the effectiveness of rehabilitation: methodology, practical experience, results. *Voprosy Kurortologii, Fizioterapii, i Lechebnoi Fizicheskoi Kultury.* 2016;93(6):12–20. (In Russ). doi: 10.17116/kurort2016612-20
17. Weigl M, Cieza A, Andersen C, et al. Identification of relevant ICF categories in patients with chronic health conditions: a Delphi exercise. *Journal of Rehabilitation Medicine.* 2004;(44 Suppl):12–21. doi: 10.1080/16501960410015443
18. Yun YN, Choi GE, Lim H. Assessment Using the ICF-core set for Children and Youth with Cerebral Palsy: A Single Case Study. *The Journal of Korean Physical Therapy.* 2019;31(2):103-10. doi: 10.18857/JKPT.2019.31.2.103
19. Van Gorp M, Roebroeck ME, van Eck M, et al. Childhood factors predict participation of young adults with cerebral palsy in domestic life and interpersonal relationships: a prospective cohort study. *Disability and Rehabilitation.* 2020;42(22):3162-71. doi: 10.1080/09638288.2019.1585971

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