

**The treatment of cerebral palsy with a special
neurorehabilitation programme**

**Report of 100 patients analysed with the Gross Motor
Function Measure**

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Abstract

The Committee for the definition of Cerebral Palsy (CP) - called Infantile Zerebralparese (IZP) in German literature – classifies this condition as an incurable neurological disorder caused by an impairment in the development of “mobility and posture” of the affected child, along with a deficiency in all motor activities. The breakdown of the motor function is usually connected to an impairment of the mental functions. The damage occurs during foetal or early childhood brain development. Treatment of children should begin early and include all possibilities of modern neurorehabilitation. The repetitive form of neurorehabilitation should be applied due to the peculiarity of the clinical picture and its usually delayed diagnosis.

This report provides information on the results for 100 patients with CP treated at ADELI Medical Center in Piešťany (AMC-P) with a special neurorehabilitation programme. The effect of the treatment programme was analysed using the Gross Motor Function Measure-88 system (GMFM-88). According to the evaluated data, all patients showed evidence of improvement in chronic impaired motor function. No patient showed deterioration. The focus of the treatment programme is on the methods of stimulating the proprioceptive system.

Introduction

According to the report of the Committee for the definition of Cerebral Palsy (CP) - called Infantile Zerebralparese (IZP) in German literature – published by Rosenbaum et al. in 2006, this condition is to be defined as a disorder of the development of mobility and posture with limitation of activities. The non-progressive impairment in cerebral activity occurs during foetal or childhood brain development. The motor disability in the foreground is often accompanied by “impairment of emotions, perception, cognition, communication and behaviour”. Often it comes to “epilepsy and secondary musculoskeletal problems”. As mentioned in the committee report the triggering damages impact the motor centres of a developing brain. For the diagnosis of cerebral palsy, the damage to the brain must not be progressive and must not “indicate the properties of an illness”. The underlying brain damage is classified as heterogeneous both in the cause as well the degree of severity [1]. The diagnosis of cerebral palsy is usually late, although the disorder in the motor development of an affected child is often identified early by relatives. A peculiarity that must be mentioned for this neurological condition is that the effects of the early childhood brain damage change with the natural development of the brain and body. The existing damage to the brain does not increase in its extent or its localisation. The disorder of motion and posture is in the foreground in the condition of CP as per the definition of the committee, usually followed by secondary damage to mobility apparatus, but also to cognitive abilities [1].

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According to the motor failures that are in the foreground, the primary focus of every therapy for cerebral palsy must be oriented towards improving the impaired motor capabilities. Every treatment programme should be introduced as soon as possible and must be implemented with complete consistency. Due to the peculiarity of the incidence of the disease, the basic principle is to repeat the treatment phases several times and thus to plan a repetitive form of neurorehabilitation.

The Gross Motor Function Classification System (GMFCS) developed by Palisano, Rosenbaum et al 1997 is recommended to record and delimit the motor failures and to analyse the effect of a therapy in cerebral palsy [2,3,4,5]. The Gross Motor Function Classification System is a standardised, well-validated, well thought out system that is reliable for the analysis to classify the motor impairment in children. The system works on a five-point scale and considers the motor range of childhood development (2). This makes it possible to make a forecast statement. The collected data can also be referred to estimate a defect condition [2,4]. An extension was suggested in GMFCS- E&R by Palisano, Rosenbaum et al 2007 [6]. The degree of mobility of children at home as well as in school and in the social environment can be recorded well with the extended and revised Gross Motor

Function classification system (GMFCS- E & R).

The Gross Motor-Function Classification System is based on self-initiative movements. Five categories have been used as initial basis, which are important for daily life and represent the expression of basic motor activities. The category 1 is related to lying and rolling, the category 2 to crawling and kneeling, the category 3 to sitting, the category 4 to standing and the category 5 to walking, running and jumping.

Each of the starting points is oriented towards the forward movement options of a child that are characteristic after the child is 6 years old. The motor options and their limitation are broadly created for each age class. The classification system does not collect all movement details of the impaired motor functions of a patient [2,6]. A child with hemiparesis unable to crawl on the hands and knees but with the ability of pulling himself up and walking is classified in starting category I corresponding to lying and rolling, irrespective of the age. A similar process is also applied to other categories. The category walking, running and jumping, listed as category V is omitted for children below two years of age.

Russel et al.1989 developed the Gross Motor Function Measure Method (GMFM) [7] to quantify the impaired gross motor skills of children with CP. The original GMFM had 85 tests. Modifications were done later, more tests were added, so that the Gross Motor Function Measure method established later contains 88 tests (GMFM-88). This form, that is in use since 1990 [8] is simple to put into practice. The 88 tests are designed in such a way overall that they can be easily carried out by a normally developed five year old child [8].

The 88 tests are consolidated in five questionnaires to record motor impairments and their analysis. Each questionnaire is in tune with one of the five starting points of the GMFCS-E&R. The first questionnaire refers to lying and rolling, the second to sitting, the third to kneeling, crawling, the fourth to standing and finally the fifth to walking, running and jumping. The 88 tests listed in the questionnaire correspond to one of the five starting points. There are 17 tests for the first starting point lying and rolling, 20 tests for the second starting point of sitting, 14 for kneeling, crawling, 13 for standing and 24 for walking, running and jumping. The analysis of each of the 88 tests in GMFM-88 is done with a four-point scale from 0 to 3. The definition 0 means not initiated, 1 means initiated, but less than 10% of the tasks are fulfilled, 2 means the tasks were carried out partially at 10% but less than 100 %, 3 means: does the task. "Not tested" is also intended as an option. The highest number of points is 264 points, considering all 88 tests and maximum points awarded are three per task.

One of the five-point questionnaires is provided as an image for better

understanding of the analysis process (Questionnaire with starting point lying, rolling and 17 test items (Figure 1).

Since the addition of the results can lead to a different weighting the percentage of the possible points is calculated for every test. The five percent values obtained result in the average of the GMFM-overall value of a questionnaire.

Treatment programme of the patients with cerebral palsy conducted at the ADELI Medical Center Piestany (AMC-P)

After the repetitive neurorehabilitation for the therapy for cerebral palsy, the general applicable principle is that treatment of patients with cerebral palsy must be continued for life. The programme conducted must be oriented towards a multi-dimensional process. The categorical requirement of ensuring maintenance of the present status along with an improvement in the motor impairments is in the forefront.

Since the acute phase of brain damage is usually overlooked in case of cerebral palsy and the consequences are identified late accordingly, the absolute valid system for early rehabilitation (K. v. Wild) cannot be implemented for acute brain damage in later life. The repetitive neurorehabilitation should however be used. The repeated conducted treatment phases have to adapt to the existing neurological impairments. Care must be taken to avoid secondary impairment. The secondary consequences of brain damage are denoted in literature as Bed Rest syndrome (9) with the detailed symptoms of polyneuropathy, secondary encephalopathy and secondary lesion of the spinal cord as well as further consequences of primary muscle atrophy, contractures of various joints and impaired development of the spine.

This report provides information on the analysis of data collected from 100 patients with CP, after neurorehabilitation treatment at ADELI Medical Center in Piešťany, Slovakia (AMC-P) using a repetitive neurorehabilitation system with treatment phases of approx. 3 weeks.

The 100 patients involved in the study consistently had the characteristic symptoms of CP with spasticity of the legs. The patients had prior treatment at different centres in Central Europe and were accepted in AMC-P for special therapy. The motor deficit was classified in the groups I-IV as per the Gross Motor Function Classification System (GMFCS-E&R) corresponding to medium severe to severe motor deficit. The age groups were between 4 years to 14 years with focus on 9-12 year olds.

According to the conditions for admission to the ADELI Center, every CP patient undergoes a paediatric and neurological investigation after detailed admission case history. An individual neurorehabilitation programme is prescribed based on these prior investigations taking into consideration the findings. The number of detailed therapies to be planned and the intended treatment duration is specified in the respective programme. The experiences of those involved with the present treatments are also included.

A multi-disciplinary team drives the therapy programme at AMC-P and is led by a special neurologist with experience in neurorehabilitation for CP, or a physical medicine consultant with experience in CP. Three treatment teams work in parallel at the ADELI Center. The treatment programme is conducted by two to four physiotherapists for each patient, in line with the programme details and any eventual problems of the respective patients. A masseur as well as a therapist for speech therapy and for extended reflex zone therapy is available in the team. The duration of treatment is between 4 ½ and 6 hours per day for every patient. The treatment is done 6 days a week.

The treatment system differentiates between a fixed and detailed variable detail programme. The focus lies on the different methods for stimulating the proprioceptive system. The options of physiotherapy and ergotherapy are also included. Every patient gets a treatment time of 30 minutes in all areas of detail. A complete body massage of 40-minute duration is planned daily in the basic programme. Furthermore, cold-warm packs and sulphur mud treatments are provided daily for 20 minutes respectively. Every alternate day the individual patient receives a manual therapy programme lasting 30 minutes with the target of mobilising joints, extremities and the spine.

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Transcranial magnetic stimulation and transcranial electro stimulation of 20 minutes respectively are also possible every day. A speech therapy session of 40 minutes duration can also be planned in the programme. Biofeedback therapy based on EEG over 40 minutes can take place every alternate day. The Galileo method is used for individual patients. The treatment programme is discussed in detail with the rest of the team members by the doctor responsible for the team. The accompanying relatives are included in the programme and take part in the team discussions. Neurological monitoring is planned weekly for each patient.

The focus of the treatment of patients with CP lies on the stimulation methods of the proprioceptive system. The scientific basis for this is the knowledge about the effect of an activation of the sensorimotor areas of the cerebrum through stimulation of the proprioceptive receptors, proven with the help of the functional MRI method (fMRI) of Golaszewski et al [10]. Regulation of the impaired motor functions is assumed through the stimulation effect. The Adeli gravity device (suit) with stimulation effect of the receptors in the areas of the extremities and the spine is used for stimulating the proprioceptive systems. Methods of reflex therapy of the soles of the feet and the hands are applied as further options for stimulation. A vibration shoe is also available. The Galileo vibration method is used for individual patients.

The method of hyperbaric oxygen therapy (HBOT) has been set up recently at the ADELI Medical Center as additional therapy for patients with CP. The

planning and conducting of this form of therapy is according to the principles formulated by the Hyperbaric Neuromedical Centre Fort Lauderdale, Florida [11]. An anaesthetist specialised in HBOT and two specially trained nurses work for the HBOT department and are supported by the team responsible for the technical support of the HBOT chamber. 90 minutes per session are provided daily for an HBOT treatment.

Analysis of the treatment data collected from 100 patients with CP through the GMFM-88

The data of the 100 patients accepted in the study and treated between January 2008 and January 2011 was analysed according to the guidelines of the Gross Motor Function Measure Score using a scoring key of the score sheet (GMFM 88 Scoring) and evaluated using SPSS™ Version 17.0. The Kolmogorov-Smirnov test was used to check the normal distribution. The Wilcoxon test was used to compare the test results of the GMFM-88 before and after the treatment. The five sub-groups of the GMFM-88 were compared with each other.

The distribution in degree of severity and age of the patients was foregone in the detailed evaluation of the individual categories. As per the inclusion criteria for the 100 patients with cerebral palsy in the study, the results showed that all cases with cerebral palsy had clear motor deficit. Due to the global consolidation of test prerequisites, the details of the symptomatology could be left out. The prominent symptom in all patients was spasticity of the lower extremities with additional spastic symptoms in the arm area. Cerebellar and extrapyramidal symptoms as well as cognitive impairment were not to be considered due to the overall concept of the GMFM-88 in the evaluation of this data.

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While analysing the individual results of the progression of the treatment the data collected with the GMFM method before beginning the therapy was compared with the data collected after the treatment programme was conducted. The treatment phase stretched over three weeks (10 to 20 days). To have a percentage basis, the results of the tests were divided by the highest points to be achieved, enabling a better overview of the results of the treatment. To provide a specific example, 100% corresponds to a complete and unimpaired function in the individual test areas, while 0 % in the same test area indicates complete failure of the tested movements.

Results of the evaluation with GMFM-88

The data achieved with the 100 patients suffering from CP and collected with the GMFM-88 method is consolidated in the table 1 (Tab.1) and represented graphically in figure 2 (Fig.2):

The results of the tasks were listed separately in the different starting categories of the tests such as lying, sitting, walking etc. The calculated percentage of the evaluation of the results is drawn over the entire collective. The initial value for the individual patients is compared with the value after the treatment. The comparison refers to the values of the overall collective.

In starting category I (lying, rolling) an overall result of 82.76% was achieved after therapy with an average starting value of 75.06% of the overall collective. The detailed results vary between 9.8% to 100% before the therapy and 19.61% and 100% after the therapy.

In starting category II (sitting position) the average initial value before the therapy was 51.01% with individual values from 0% to 100%. The values after the therapy increased to 59.90% with individual values from 0% to 100%.

In starting category III (position on the knees on all fours, crawling) the initial value of the overall collective was 40.14% (0% to 100% as individual values) with an increase in the value of the overall collective to 47.14% (0% to 100% as individual values).

In starting category IV (standing) an initial value of 20.62% (0% to 84.62% as individual values) was determined, with an increase in the collective value to 27.59% with individual values from 0% to 93.18% after the therapy.

In starting category V (walking running, jumping) the value of the overall collective was 13.85% with individual values from 0% to 83.33% before the therapy and increased to the value 17.14% for the overall collective after the therapy, with individual values from 0% to 92.71%.

To summarise and provide an overview of the results of the analysis of the GMFM-88 test questionnaires collected from 100 patients with cerebral palsy treated at the ADELI Medical Center Piešťany: there was overall improvement in all 5 test categories. This should be classified as significant ($p < 0.01$). The processing of the large number of test documents in the different starting categories had the advantage of offering a better insight into the impaired movement. None of the patients showed deterioration in the motor impairment in any of the five initial categories.

Discussion of the results

Thus the result of the evaluation of the data collected with the help of the GMFM-88 method showed that a high percentage of positive effect could be achieved with the treatment in 100 patients with distinct impairment in line with CP after treatment at ADELI Medical Center Piešťany and documented with the Gross Motor Function System (GMFCS-E&R). All patients had distinct spasticity in both legs as stated earlier. Some patients had already undergone prior treatments.

The treatment programme at ADELI Medical Center Piešťany focuses on the stimulation of the proprioceptive system, and includes different additional methods of physiotherapy. Particular emphasis is laid on specific individual treatment while observing timelines. The therapy is conducted at AMC-P by an experienced treatment team. 2-4 trained physiotherapists work to support individual patients and are supervised by a specialist trained particularly in neurorehabilitation and responsible for the individual team. A substantial effort in terms of time of 4 ½ to 6 hours per treatment session is maintained as the basic principle and is provided 6 days every week. Particular mention must be made about the integration of one of the accompanying relatives in the treatment team with training in the treatment programme.

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The strict treatment programme conducted by a trained team involving one of the parents must be highlighted as an explanation for the positive results of the for treatment. The great effort in terms of the treatment time and the treatment being conducted by at least two experienced, well trained experts for each patient, with continuous contact with the doctor responsible for the individual team is a basic prerequisite for the favourable results of the treatment. The use of methods for stimulating the proprioceptive system must be underlined and stressed as an important component of the treatment programme.

Confinement to bed for longer duration – described by Gerstenbrand in case of traumatic apallic syndrome – causes the so-called bed-rest syndrome characterised by primary loss of muscle, symptoms of polyneuropathy and symptomatology of posterior column impairment.[14]

The inclusion of methods for stimulating the proprioceptive system in neurorehabilitation for treating motor impairment is based on the knowledge about regulatory influence through stimulation of the feedback system of motor activity, the proprioceptive system with activation of the sensomotor centres of the human brain, with simultaneous activation of different other cerebral areas and the control centre of the thalamus as well as the cerebellum.

Reporting on a relatively low number of patients with CP after a completely successful neurorehabilitation treatment appears justified considering the topic of

cerebral palsy. It also needs to be mentioned that the condition is usually perceived late in the affected children, the treatment is started with delay, the motor as well as the accompanying neurological impairment is usually chronic, secondary damage to the motor activity as well as the movement system along with the not unusual accompanying mental impairment are seen as fate. Secondary damage could be prevented at least partially in individual affected children with timely treatment. The clinical picture of cerebral palsy lies on the fringes of neurology and paediatrics. The attitude of the midwife has an additional negative effect and delays the start of treatment programmes. Moreover, it must be accepted that the number of experienced neurologists or paediatric neurologists with knowledge of neonatology is very small and this area is neglected not only doctrinally but also in research. Added to this is the preconception that still exists that damage to the brain of an infant is often classified as reversible.

The fact that there are no special centres set up for patients with cerebral palsy is very significant in the final analysis for the less dynamic support for this relatively large number of children. It therefore appears justified to report on options for treatment supported by a careful analysis. More research on timely diagnosis – primarily through the special neurorehabilitation of this relatively frequent condition - is necessary. This is a condition that represents a lifelong burdened fate for many people and their relatives.

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Check (✓) the appropriate score: if an item is not tested (NT), circle the item number in the right column

Item	A: LYING & ROLLING	SCORE				NT
1.	SUP, HEAD IN MIDLINE: TURNS HEAD WITH EXTREMITIES SYMMETRICAL.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	1.
* 2.	SUP: BRINGS HANDS TO MIDLINE, FINGERS ONE WITH THE OTHER.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	2.
3.	SUP: LIFTS HEAD 45°.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	3.
4.	SUP: FLEXES R HIP AND KNEE THROUGH FULL RANGE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4.
5.	SUP: FLEXES L HIP AND KNEE THROUGH FULL RANGE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	5.
* 6.	SUP: REACHES OUT WITH R ARM, HAND CROSSES MIDLINE TOWARD TOY.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	6.
* 7.	SUP: REACHES OUT WITH L ARM, HAND CROSSES MIDLINE TOWARD TOY.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	7.
8.	SUP: ROLLS TO PR OVER R SIDE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	8.
9.	SUP: ROLLS TO PR OVER L SIDE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	9.
* 10.	PR: LIFTS HEAD UPRIGHT.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	10.
11.	PR ON FOREARMS: LIFTS HEAD UPRIGHT, ELBOWS EXT., CHEST RAISED.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	11.
12.	PR ON FOREARMS: WEIGHT ON R FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	12.
13.	PR ON FOREARMS: WEIGHT ON L FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	13.
14.	PR: ROLLS TO SUP OVER R SIDE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	14.
15.	PR: ROLLS TO SUP OVER L SIDE.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	15.
16.	PR: PIVOTS TO R 90° USING EXTREMITIES.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	16.
17.	PR: PIVOTS TO L 90° USING EXTREMITIES.....	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	17.
TOTAL DIMENSION A						<input style="width: 100px; height: 20px;" type="text"/>

Figure 1. Example from the five-point scoring questionnaire provided as image (questionnaire with initial position lying/rolling with 17 test items).
 SUP: supine position, PR: prone position

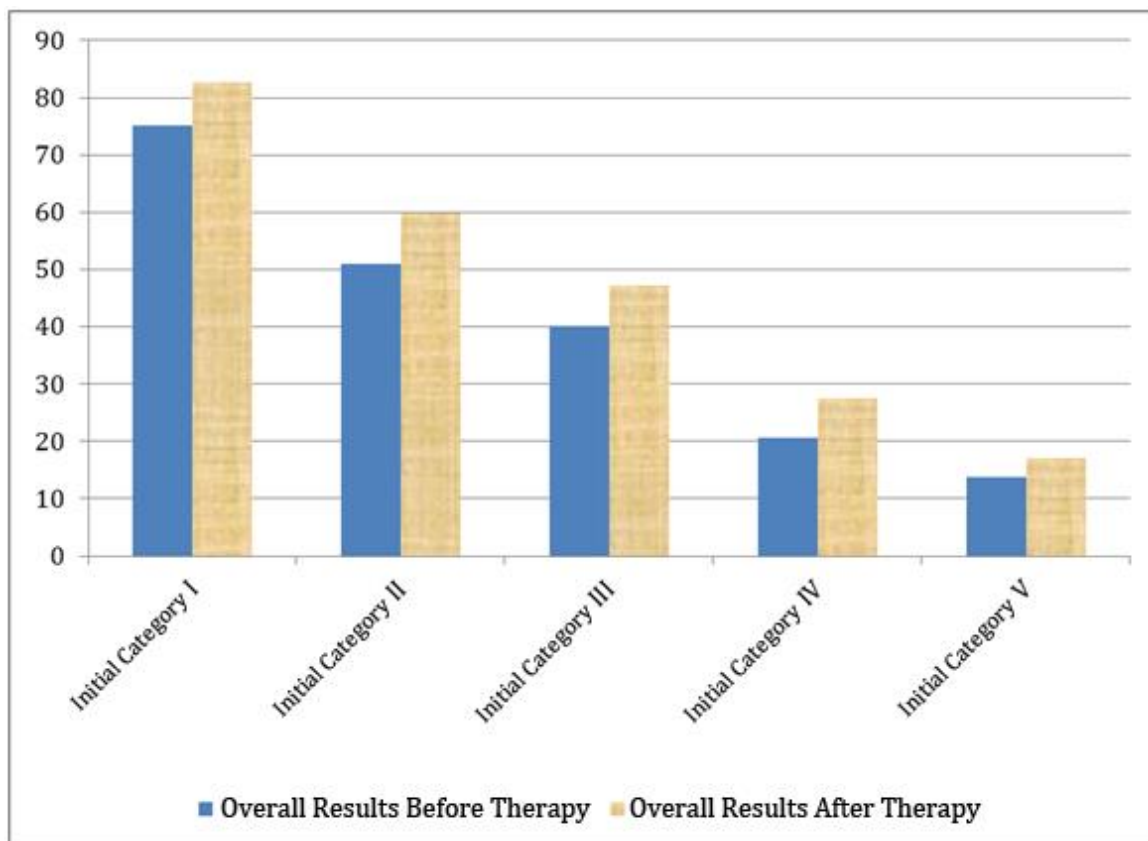


Figure 2. Column chart with baseline values before the therapy (blue bars) and after the therapy (brown bars) of 100 patients with cerebral palsy from data collected with the GMFM-88 method. The comparison is with reference to the overall collective values. The initial category I concerns lying and rolling, the category II crawling on the knees, the category III sitting, the category IV standing, the category V walking, running and jumping.

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Initial-category	Before therapy			After therapy			p
	Average	Maximum	Minimum	Average	Maximum	Minimum	
I	75.06	9,8	100	82.76	19,61	100	< 0,01
II	51.01	0	100	59.9	0	100	< 0,01
III	40.13	0	100	47.14	0	100	< 0,01
IV	20.61	0	84,62	27.59	0	93,18	< 0,01
V	13.84	0	83,33	17.14	0	92,71	< 0,01

Table 1. Table with the results before and after therapy of 100 patients with cerebral palsy from data collected with the GMFM-88 method. The comparison is with reference to the overall collective values. The probability (p) was calculated using the Wilcoxon signed-rank test.

The initial category I concerns lying and rolling, category II crawling on the knees, category III sitting, category IV standing, category V walking, running and jumping.