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# Assessment of Functional Performance in Children with Cerebral Palsy Receiving Treatment in a Day Care Facility: An Observational Study

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**Background:** The study assessed changes in functional performance of children with cerebral palsy (CP), immediately following treatment and 2 months later, in addition to investigating the relationship between therapy effect and sex, age, or comorbidities.





**Material/Methods:** Functional performance of 32 children with spastic diplegia CP, aged 9-16 years, was assessed for: 1) manual function (Box and Block test), motor capacities (Gross Motor Function Measure), sensory capacities (Finger Identification [FI] and Localisation of Tactile Stimuli test [LTC]), and 2) activity and participation, ie, independence in essential and more complex daily activities (Barthel Index; Paediatric Evaluation of Disability Inventory). Measurements were conducted before the start (Month 0), immediately after 6-month rehabilitation program (Month 6), and following a 2-month period with no therapy, ie, 8 months after baseline measurement (Month 8).  
**Results:** Comparison of Month 0 and Month 6 scores showed significant differences ( $P < 0.001$ ) in all measures. However, Month 8 scores were significantly worse in all the measures, except for sensory capacities assessed using FI and LTC ( $P < 0.001$ ).

**Conclusions:** Functional performance of children with CP was positively affected by 6-month therapy, but 2 months later these effects significantly deteriorated, except for the sensory capacities. This suggests that therapy focusing on functional performance should be included as a permanent component of rehabilitation programs. These findings may be important for clinical practice as they show that therapy of children with CP should be continuous and systematic, and this should be taken into account by those designing therapeutic programs.

**Keywords:** **Cerebral Palsy • Motor Skills • Motor Skills Disorders • Physical Functional Performance • Rehabilitation**

**Abbreviations:** **CP** – cerebral palsy; **MACS** – Manual Ability Classification System; **PEDI** – Pediatric Evaluation of Disability Inventory; **GMFCS** – Gross Motor Function Classification System; **GMFM** – Gross Motor Function Measure; **NDT-Bobath** – Neuro-Developmental Treatment; **PNF** – Proprioceptive Neuromuscular Facilitation; **SI** – Sensory Integration therapy; **FI** – finger identification test; **LTC** – localisation of tactile stimuli test

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## Background

Cerebral palsy (CP), is a heterogeneous group of disorders caused by early brain damage that lasts a lifetime. According to various authors, the incidence of CP is estimated at 1.5-3.3 cases per 1000 live births [1]. In Poland, the incidence of CP is estimated at 2.0-2.5 per 1000 live births [1,2]. CP resulting from a non-progressive lesion occurring in an immature brain is recognized as a disorder most severely affecting motor and postural control [3]. Due to this, therapy of children with CP aims to improve their independent mobility, performance of daily activities, and participation in social life. There are many factors promoting motor improvement in children with CP [4,5]. Effectiveness of various types of therapy intended for patients with CP was assessed in many studies [4-13]. However, most of these did not provide solid evidence related to effectiveness due to the heterogeneity of the study groups, other limitations associated with the type of therapy provided, and the duration of the rehabilitation program [4-8]. This observation encouraged us to investigate this subject matter more extensively.

Functional barriers faced by patients with CP are to a greater or lesser extent associated with their abilities related to gross and fine motor skills [14-16]. Additionally, motor disorders in children with CP are often accompanied by abnormalities connected with sensory integration, body schema, tactile function, communication, perception and behavior [14].

Identification and assessment of functional impairments in children with CP are facilitated by appropriate diagnostic tools, which can also be used to evaluate effects of therapies. The tools most commonly used to identify abnormalities in fine and gross motor skills presented by children with CP include the Gross Motor Function Classification System (GMFCS), Gross Motor Function Measure (GMFM), Manual Ability Classification System (MACS), and Paediatric Evaluation of Disability Inventory (PEDI) [17].

Today, rehabilitation of patients with CP is largely based on neurodevelopmental methods, such as Neurodevelopmental Treatment Bobath (NDT/Bobath), Proprioceptive Neuromuscular Facilitation (PNF), and Sensory Integration (SI), involving sensory stimulation and activation and affecting the patient's proprioception and kinaesthesia [18-23].

We were also motivated to investigate long-term effects of rehabilitation – to assess patients' status at baseline, at the end of a 6-month program, and after 2 months without therapy – by the fact that there is a lack of research reports evaluating various therapeutic methods for durability of effects and applying various tools measuring the therapeutic effects in children with CP. Furthermore, no research reports have presented unequivocal conclusions related to the effects of continued therapy versus

rehabilitation programs including periods with no therapy on performance of children with CP [6]. The expected implications of our study for the clinical practice include the fact that the findings may provide information which will be helpful for therapists and parents planning therapy of children in CP, and may also be important in the process of designing therapeutic programs in facilities providing treatment to this population of children.

Many studies present information on the relationship between age, sex, or comorbidities and motor performance, physical activity, or quality of life in children with CP [24-32]. Age may be an important factor associated with delayed development of balance, postural control, and selective motor control in younger children with CP; this may adversely affect acquisition of certain skills. On the other hand, adolescents may have more advanced soft tissue contractures and deformities in joints, preventing improvement in gait and other functions, irrespective of muscle strength [24]. Also, comorbidities such as obesity and cardiovascular diseases can lead to reduced activity and impair the quality of life in children with CP [24,25]. Given the above, we believe there is a need to investigate whether the effect of therapy is related to sex, age, and coexisting conditions.

The aim of this study was to assess changes in the functional performance of children with spastic diplegia CP, at the end of treatment and 2 months later, in addition to investigating whether the effect of therapy is related to sex, age, and coexisting conditions. In connection to this we formulated the following hypotheses:

1. Six-month therapy improves functional performance of children with spastic diplegia CP.
2. Two-month period with no therapy adversely affects functional performance of children with spastic diplegia CP.
3. Effect of therapy is related to the subjects' sex, age, and coexisting conditions.

## Material and Methods

### Ethics Statement

The project was approved by the local Bioethics Commission of the Medical Faculty (11/01/2021). Written consent was obtained from all the parents or legal guardians of the children, after they were informed of the study objectives. Participants aged 16 signed an informed consent form as well. Experimental conditions conformed to the Declaration of Helsinki.

### Design

The prospective longitudinal non-randomized study involved a single group.

## Procedure

The study was carried out in a special educational facility in the Podkarpackie Region, Poland. The children's functional performance associated with manual, motor, and sensory capacities, as well as essential and complex activities of daily living, were measured 3 times. The consecutive measurements were conducted in 3 points of time, ie, before the start of the rehabilitation (Month 0), immediately after the 6-month rehabilitation program was completed (Month 6), and 2 months after the therapy was completed (2-month period with no therapy), ie, 8 months after the baseline measurement, (Month 8). All the children were provided with orthopedic braces worn on the lower limbs as a support for the therapy process. The braces were selected specifically for each child. Three-time assessment of each participant was carried out in the same conditions. All the participants received treatment from the same physiotherapist, and were assessed by one examiner who performed measurements 3 times, at time intervals as described above. Rater calibration was performed using the Kappa coefficient. The acquired result exceeded a value of 0.91, which showed measurement repeatability of over 91%, reflecting high reliability and agreement of the measurements.

## Participants

The study group comprised 32 children with spastic diplegia cerebral palsy, and mild to moderate intellectual disability, presenting GMFCS level II-III. **Table 1** presents the characteristics of the study group.

### Inclusion criteria:

- written consent obtained from the children's parents or legal guardians, after they were informed about the study objectives, and from participants aged 16 after they were informed of the study objectives;
- diagnosed cerebral palsy, in accordance with medical records;
- diagnosed form of diplegia, specified in a neurological assessment and medical records;
- current health status permitting the child to participate in the examinations;
- age 9-16 years;
- participation in a uniform rehabilitation program;
- two-month break after the rehabilitation program.

### Exclusion criteria:

- significantly impaired higher mental functions and the child's unwillingness to participate in the examinations;
- hemiplegia, tetraplegia;
- surgical intervention in the area of lower and upper extremities less than 12 months before the baseline examination, and botulinum toxin treatment less than 12 months before the baseline assessment;

**Table 1.** Sample characteristics.

Characteristic of participants	n=32
Age (yr), mean (SD)	13.81 (1.63)
Gender, n (%)	
Males	21 (65.6%)
Females	11 (34.4%)
Education, n main stream (%)	
3 <sup>rd</sup> grade	1 (3.1%)
4 <sup>th</sup> grade	1 (3.1%)
5 <sup>th</sup> grade	5 (15.6%)
6 <sup>th</sup> grade	6 (18.8%)
7 <sup>th</sup> grade	5 (15.6%)
8 <sup>th</sup> grade	14 (43.8%)
GMFCS, n (%)	
Level II	19 (59.4%)
Level III	13 (40.6%)
MACS	
Level I	11 (34.4%)
Level II	11 (34.4%)
Level III	10 (31.3%)
Cognitive, n (%)	
Mild impairment	17 (53.1%)
Moderate impairment	15 (46.9%)
Comorbidities	
Epilepsy	1 (3.1%)
Insulin dependent diabetes	1 (3.1%)
Visual disorder corrected with glasses	5 (15.6%)
Auditory limitations	5 (15.6%)

GMFCS – Gross Motor Function Classification Scale;

MACS – Manual Ability Classification System.

- no comorbidities such as rheumatic, oncological, and cardiological diseases as well as pain and inflammation in the musculoskeletal system.

## Intervention

The therapy was conducted for 6 months, with 45-minute sessions taking place 5 times per week; the program included individual therapy based on NDT/Bobath and PNF methods (4 times per week) and sensory integration therapy (once a week) (**Table 2**). The sessions were designed specifically for

Table 2. Therapy program.

Month/ individual therapy	Week/ 4 sessions, 45 minutes each	Individual therapy based on NDT/Bobath and PNF, designed to strengthen the muscles of the torso, and upper/ lower limbs. Gait training	Individual therapy based on NDT/Bobath and PNF, with exercise focusing on relaxation of quadriceps, hamstring, iliopsoas and pectoral muscles	Individual therapy based on NDT/Bobath and PNF, with exercise focusing on pelvis mobility	Exercise aimed to develop fine motor skills and improve performance in activities of daily living (dressing, undressing, personal hygiene)	Sensory integration (haptic stimulation, massage applying various textures, vestibular stimulation)	Duration per week
I	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	10	45	5×45 min
<b>Total</b>		<b>80 min×4</b>	<b>40 min×4</b>	<b>20 min×4</b>	<b>40 min×4</b>	<b>180 min</b>	
II	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	1	45	5×45 min
<b>Total</b>		<b>80 min×4</b>	<b>40 min×4</b>	<b>20 min×4</b>	<b>40 min×4</b>	<b>180 min</b>	
III	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	10	45	5×45 min
<b>Total</b>		<b>80 min×4</b>	<b>40 min×4</b>	<b>20 min×4</b>	<b>40 min×4</b>	<b>180 min</b>	
IV	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	10	45	5×45 min
<b>Total</b>		<b>80 min×4</b>	<b>40 min×4</b>	<b>20 min×4</b>	<b>40 min×4</b>	<b>180 min</b>	
V	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	10	45	5×45 min
<b>Total</b>		<b>80 min</b>	<b>40 min</b>	<b>20 min</b>	<b>40 min</b>	<b>180 min</b>	
VI	I	20	10	5	10	45	5×45 min
	II	20	10	5	10	45	5×45 min
	III	20	10	5	10	45	5×45 min
	IV	20	10	5	10	45	5×45 min
<b>Total</b>		<b>80 min×4</b>	<b>40 min×4</b>	<b>20 min×4</b>	<b>40 min×4</b>	<b>180 min</b>	
<b>Total duration</b>		<b>32 h</b>	<b>16 h</b>	<b>6 h</b>	<b>16 h</b>	<b>18 h</b>	

each participant and aimed to improve motor functions, balance, gait, fine motor skills, and performance in activities of daily living, and to develop the spatial and body schema orientation by stimulating the senses (touch, proprioception). The sessions were held in a therapy room at the facility. No therapy session had to be ended earlier, and no undesired incidents occurred.

### Outcome Measures

The assessment, based on International Classification of Functioning, Disability and Health (ICF) and taking into account the 3 components – body functions, activity and participation – was carried out with the use of the tools which have been validated and recommended for use in research studies [24,32-37]. All the tests were applied in conformity with the instructions for the questionnaires and tests, described below, by certified therapists authorized to perform them.

#### 1. Function:

- manual – Box and Blocks test, which makes it possible to examine dexterity and fine motor coordination. To perform the test, you need 2 boxes of equal dimensions, separated with a 15-cm-high partition. One of the boxes is filled with 150 wooden cubes. The subject is asked to move as many cubes as possible from one box to the other during 60 seconds [31,33].
- motor – GMFM-66 scale, which is used to assess the motor function in children with CP. The scale comprises 66 motor tests corresponding to 5 dimensions: A – Lying and rolling, B – Sitting, C – Crawling and kneeling, D – Standing, and E – Walking, running, and jumping. Each motor activity performed by the child is rated on a 4-point scale: 0 is awarded if the subject does not initiate the activity; 1 – if the task is initiated; 2 – if the task is partially completed, and 3 – if the task is completed [24,32].
- sensory – Southern California Sensory Integration tests, comprising:
  - a) Finger identification test (FI), which assesses tactile perception and somatognosis; the subject is asked to indicate which of his/her fingers was touched by the therapist. The examiner covers the subject's hands during the trial and touches selected fingers. Subsequently, the subject looks at his/her hands, touches them, and decides where the stimulus was applied [33,34].
  - b) Localization of tactile stimuli test (LTC), which assesses tactile perception and spatial orientation – the therapist covers the subject's arm, so that he/she cannot see where he/she is being touched, and then touches the subject's hand or forearm with a pen or marker to leave a small trace on the skin. Next, the examiner asks the subject to show the place which was touched by the therapist. After the subject points to the place, the examiner measures the distance

between the location marked with the pen, and the place indicated by the subject [33,34].

#### 2. Activity:

- functional independence – Barthel Index, which assesses performance in essential activities of daily living. The scale consists of 10 items; in each case the lowest rating (0 points) corresponds to complete inability to perform the activity, or a total dependence on others. A maximum of 100 points can be scored [35].
- functional independence – PEDI scale, which assesses performance in complex activities of daily living in children with various motor deficits. It comprises 3 measuring parts: Functional skills (self-care, mobility and social function), Caregiver assistance, and Modifications. A score of 0 corresponds to a lack of task performance or very limited performance in most instances. A score of 1 indicates that the child effectively performs the task [36,37].

#### 3. Participation:

- social contacts were tested using the PEDI scale; the relevant items assessed the ability to understand words and complex sentences, use communication in practice, express one's needs and emotions, solve problems, interact with peers, and play with objects, as well as self-knowledge and orientation in time. A score of 0 corresponds to a lack of task performance or very limited performance in most instances. A score of 1 reflects that the child effectively performs the task [36,37].

### Sample Size

The minimum sample size for the population investigated was determined using a sample size calculator ("PLUS module" from Statistica 13.3 software), taking into account the number of children with spastic diplegia CP attending the special educational facility in the Podkarpackie Region, Poland. A fraction size of 0.8 was used, with a maximum error of 5%, and a 95% confidence level, and a sample size of 30 patients was obtained. The study involved 32 children. The following formula was applied to determine the minimum sample size:

$$N_{min} = \frac{NP(\alpha^2 \cdot f(1-f))}{NP \cdot e^2 + \alpha^2 \cdot f(1-f)}$$

$N_{min}$  – minimum sample size

$NP$  – size of the population from which the sample is drawn

$\alpha$  – level of confidence for the results

$f$  – fraction size

$e$  – expected maximum error

## Statistical Analysis

The research material was subjected to statistical analyses using Statistica 13.1. Non-parametric tests were applied in analyses of the variables and the values. This type of testing was performed due to the failure to achieve primary assumptions of parametric tests, ie, compatibility of the distributions of the relevant variables with the normal distributions, which were examined and verified using the Shapiro-Wilk W test. For most of the numerical variables, the following descriptive statistics were calculated: arithmetic mean, minimum, maximum, standard deviation, median, and 1<sup>st</sup> and the 3<sup>rd</sup> quartile. The statistical interpretation of the evaluations in the 3 consecutive periods was verified using non-parametric Friedman's ANOVA. Because a statistically significant disproportion was identified, a subsequent post hoc test was run; in the case of Friedman's ANOVA, it was Dunn's test. It confirmed or contradicted the presence of statistically significant disparities between the results of the consecutive measurements. The Mann-Whitney U test was applied to assess the typically differentiated numerical characteristics of the 2 populations. To interpret the differences in the statistical level of a numerical characteristic in more than 2 populations, the Kruskal-Wallis ANOVA was applied. In this case, multiple comparisons were run as the post hoc test. The relationship of 2 unknowns failing to meet normal distribution criteria was assessed using Spearman's rank correlation coefficient. Kappa coefficient was applied to assess agreement among 3 measurements performed by the examiner. Statistical significance was assumed for  $P < 0.005$ .

## Results

### Study Participants

The study group included 11 (34.4%) girls and 21 (65.6%) boys diagnosed with spastic diplegia CP and mild to moderate intellectual disability, ranging in age from 9 to 16 years (13.81 years  $\pm$  1.64 month), participating in a rehabilitation program carried out in a special educational facility. All the children were in primary school, most in the 8<sup>th</sup> grade (14 [43.8%]), and decreasing numbers were in the lower grades. Assessment with GMFCS showed that 19 children (59.4%) were at Level II, and 13 (40.6%) were at Level III. MACS Level I and II each were identified in 11 children (34.4%), while 10 (31.3%) children were at Level III. Mild and moderate intellectual disability was identified in 17 (53.1%) and in 15 (46.9%) children, respectively (Table 1).

### Changes in the Functional Performance at the End of Treatment and 2 Months Later

The results in all the scales and functional tests applied in the consecutive measurements, ie, before the rehabilitation – Month 0, immediately after the 6-month therapy – Month 6, and at the end of the two-month period with no therapy, ie, 8 months after the baseline measurement – Month 8, were examined using Kruskal-Wallis ANOVA test, which showed the scores were not equal ( $P < 0.001$ ). Therefore, it was necessary to further analyse the results using a post hoc test, in this case Dunn's test.

### Results for Barthel Index, GMFM as Well as Box and Block (Month 0, Month 6, Month 8)

The interpretation of post hoc test results for Barthel Index, GMFM, as well as Box and Block for the right and the left limb was uniform. A statistically significant change was observed in the results measured immediately after the 6-month therapy, compared to Month 0 and the change was associated with improvement in the scores obtained by the children in the consecutive scales/functional test (the difference: Month 6 minus Month 0). Furthermore, the abovementioned tests showed a statistically significant change in the results achieved by the children in the measurement at the end of the 2-month period with no therapy relative to the measurement performed immediately after the 6-month therapy. This time the change was negative. This means that the 2-month break in the therapy resulted in a significant deterioration of the scores identified immediately after the therapy (Month 8 vs Month 6). In the case of these tests, no differences were found between Month 0 and Month 8 measurements. This means that the results in Month 8 did not differ from the baseline identified before the therapy, which shows that because the rehabilitation was discontinued (the period between Month 8 and Month 6), the children's functional status was the same as before the therapy (Table 2).

### Results for SI Tests (Month 0, Month 6, Month 8)

The interpretation for 2 other tests, ie, SI (FI and LTC) was also uniform. This time there were statistically significant changes in the results obtained by the children in the measurement immediately after the 6-month therapy relative to the baseline (Month 6 minus Month 0) and in the scores identified at the end of the 2-month period with no therapy relative to the baseline (Month 8 minus Month 0). No significant differences were found between the scores obtained by the children immediately after the 6-month therapy and at the end of the 2-month period with no therapy (Month 8 vs Month 6). This means that the scores in SI tests reflected a statistically significant improvement achieved by the children immediately after

**Table 3.** Functional tests and scales at the 3 points of time.

	Month 0 (n=32)		Month 6 (n=32)		Month 8 (n=32)		Kruskal-Wallis test		Month 6 minus Month 0		Month 8 minus Month 6		Month 8 minus Month 0	
	Mean	SD	Mean	SD	Mean	SD	H	p	Mean	SD	Mean	SD	Mean	SD
<b>Barthel</b>	61.88	22.87	67.72	22.16	63.47	23.35	42.00	<0.001	5.84*	4.54	-4.25*	4.81	1.59	2.63
<b>GMFM</b>	56.69	25.81	63.28	27.52	56.81	26.70	45.79	<0.001	6.59*	3.38	-6.47*	4.27	0.12	4.12
<b>PEDI</b>	65.56	22.92	68.50	22.08	67.41	22.36	42.28	<0.001	2.94*	3.02	-1.09*	1.30	1.84*	2.49
<b>SI – FI</b>	20.28	7.27	23.19	7.15	22.94	7.21	37.46	<0.001	2.91*	1.77	-0.25	0.67	2.66*	1.98
<b>SI – LTC</b>	5.50	2.29	6.81	2.10	6.44	1.88	45.39	<0.001	1.31*	0.64	-0.38	0.71	0.94*	0.80
<b>Box and Block – right</b>	49.16	9.45	51.38	8.83	48.56	8.75	41.29	<0.001	2.22*	1.64	-2.81*	2.44	-0.59	2.24
<b>Box and Block – left</b>	48.88	9.46	51.06	8.72	47.81	8.76	32.67	<0.001	2.19*	1.75	-3.25*	2.86	-1.06	2.73

SD – standard deviation; n – number of observation. \* Statistically significant difference in Dunn test (post-hoc)  $p < 0.05$ ; SI – sensory integration; FI – finger identification test; LTC – localisation of tactile stimuli test.

**Table 4.** Sex versus effects of rehabilitation.

Scales	Males (n=21)			Females (n=11)			Mann-Whitney test
	Mean	Me	SD	Mean	Me	SD	p
Barthel	6.14	5.00	4.35	5.27	5.00	5.06	0.345
GMFM	6.29	6.00	2.99	7.18	7.00	4.12	0.779
PEDI	3.52	2.00	3.01	1.82	1.00	2.82	0.083
SI – FI	3.00	3.00	1.76	2.73	3.00	1.85	0.887
SI – LTC	1.29	1.00	0.72	1.36	1.00	0.50	0.716
Box and Block – right	2.29	2.00	1.65	2.09	2.00	1.70	0.686
Box and Block – left	2.29	2.00	1.74	2.00	2.00	1.84	0.601

Me – median; SD – standard deviation; FI – finger identification; LTC – localisation of tactile stimuli, p – significance of the differences in Mann-Whitney U test.

the therapy and that this effect was maintained in the measurement 2 months after the therapy ended. Despite a slight decrease, the scores were still significantly higher compared to the baseline (Table 2).

#### Results for PEDI Test (Month 0, Month 6, Month 8)

Finally, the scores in PEDI test were significantly improved immediately after the 6-month therapy relative to the baseline (Month 6 minus Month 0), and subsequently there was a significant decrease in the scores identified at the end of the two-month period with no therapy relative to the results identified in measurements immediately after the 6-month therapy (Month 8 minus Month 6). Although the latter decrease

was significant, it was lower than the previous increase (ie, improvement identified immediately after the therapy relative to the baseline). Hence, despite this significant decrease, the children's scores were still significantly higher than those identified at the baseline (Month 8 vs Month 0), Table 3.

#### Relationship Between the Effect of Therapy and Sex, Age, or Coexisting Conditions.

The effects of therapy were not related to the children's sex ( $P > 0.05$ ) – Table 4.

The effects of the therapy did not differ between children with and without comorbidities ( $P > 0.05$ ) – Table 5.

**Table 5.** Comorbidities versus effects of rehabilitation.

Scales	No comorbidities (n=20)			Existing comorbidities (n=12)			Mann-Whitney test
	Mean	Me	SD	$\bar{x}$	Me	SD	p
Barthel	5.60	5.00	4.48	6.25	5.00	4.83	0.590
GMFM	7.20	7.00	3.44	5.58	4.50	3.15	0.247
PEDI	2.90	2.00	2.99	3.00	2.00	3.19	0.782
SI – FI	3.10	3.00	1.77	2.58	3.00	1.78	0.510
SI – LTC	1.30	1.00	0.73	1.33	1.00	0.49	0.876
Box and Block – right	2.10	2.00	1.59	2.42	2.50	1.78	0.593
Box and Block – left	1.85	2.00	1.60	2.75	2.50	1.91	0.199

Me – median; SD – standard deviation; FI – finger identification; LTC – localisation of tactile stimuli, p – significance of the differences in Mann-Whitney U test.

**Table 6.** Age versus effects of rehabilitation.

Variables	R	P
Barthel versus age	-0.18	0.329
GMFM versus age	0.15	0.399
PEDI versus age	-0.04	0.834
SI – FI versus age	0.01	0.946
SI – LTC versus age	-0.22	0.227
Box and Block – right versus age	0.10	0.576
Box and Block – left versus age	0.04	0.835

R-value of Spearman's rank correlation; p – significance of differences; IP – finger identification; LBC – localisation of tactile stimuli.

The effect of the therapy was not related to the children's age – **Table 6**.

## Discussion

The aim of the study was to assess changes in the functional performance of children with spastic diplegia CP at the end of treatment and 2 months later, in addition to investigating whether the effect of therapy is related to sex, age, and co-existing conditions. The findings of the present study show that immediately after the 6-month therapy program children with CP showed significant improvement in manual, motor and sensory capacities and in essential as well as complex activities of daily living. Later, following a 2-month period with no therapy, the children's functional performance deteriorated significantly as reflected by all the measures, except for the sensory capacities: tactile perception and spatial orientation.

Additionally, the findings do not support the hypothesis that the effect of therapy the children with spastic diplegia CP is related to their sex, age, or comorbidities.

The rehabilitation program applied in the current study was based on a combination of NDT/Bobath, PNF, and SI therapies. The results identified immediately after the 6-month therapy showed a considerable improvement in the children, reflected by all the measures. We assume that one of the mechanisms potentially contributing to improvement in functional performance in the participants involves neuroplastic changes induced by intensive motor training [38,39]. Another mechanism positively affecting functional performance is linked to physical training, which leads to strengthening of muscles as a result of neuromuscular adaptation [40]. This is consistent with other studies which reported improvement in motor capacities in children with diplegia regularly participating in physical training [41-43]. In the present study, the effects of rehabilitation were assessed using the following research tools: GMFM, PEDI, Index Barthel Box and Block, and Southern California Sensory Integration tests. In a study by Knox et al, effectiveness of Bobath therapy applied to 15 children with CP was assessed using GMFM and PEDI questionnaires. After a 6-week rehabilitation program, improvement was achieved by all the subjects in motor abilities and self-care skills [44]. Shamsoddini and Hollisaz assessed the effect of SI therapy on gross motor skills of children with CP. The 12-week therapy results were assessed with GMFM. The authors concluded that sensory integration and vestibular stimulation produced positive results in children with CP [45]. The present findings also show satisfying results of SI therapy. The analyses showed improved sensory integration in the children with CP; the effect was identified immediately after the 6-month rehabilitation and retained at a similar level after 2-month period with no therapy.



However, the current findings show that 2 months after the therapy was discontinued there was a significant decrease in the scores, compared to those identified immediately after the therapy, with an exception of the scores in Localisation of tactile stimuli test and Finger identification test. These findings of our study may be linked to the persistent primary impairments resulting from the damage to the central nervous system (eg, muscle spasticity) [46]. It appears that effects of therapy in children with spastic diplegia CP deteriorate rapidly due to increased muscle tightness if treatment is not provided on a regular basis. Lack of exercise frequently leads to mechanical changes in muscles and tendons, reduced range of motion in joints (ie, contractures) and bone deformities [27-29]. Effects produced by lack of physical activity in individuals with CP also include decreased muscle strength, which adversely affects performance of motor tasks, such as walking or climbing stairs [24-30]. It is likely that the above observations explain our findings proving the hypothesis, which says that a 2-month period with no therapy will negatively affect functional performance of children with spastic diplegia CP. Hence, it can be argued that well-targeted continuous and systematic therapy alleviates secondary problems, allowing patients to maintain normal motor functions which lead to independent mobility of children with spastic diplegia CP, and this fact should be taken into account by those designing therapeutic programs in facilities providing treatment to this population of children.

The current findings do not prove the hypothesis about the relationship between age, sex or comorbidities and effects of therapy. This may be linked with the fact that the groups, which were compared, were not equal in size. There were significantly more boys than girls (21 vs 11) in our study group and more children without comorbidities such as epilepsy, diabetes, visual disorder, or auditory limitations (20 vs 12). Therefore, the related research should be continued in equal-size groups representing the specific characteristics, because it seems that children's age may indeed considerably impact therapy effects. This is associated with the specificity of problems experienced at different stages of development, and affecting individuals' ability to acquire certain skills or improve certain functions, eg, the delayed development of balance, postural control and selective motor control in younger children with CP versus more advanced soft tissue contractures and deformities in joints in adolescents with CP [46]. It has also been reported that comorbidities can lead to reduced level of activity and poorer quality of life in subjects with CP [46-48].

To recapitulate the above observations and the present findings and to ensure the best quality of treatment and the most beneficial effects of therapy for the child, it is necessary to perform detailed and accurate functional assessment of the child, by using tests and scales tailored to and designed for patients with CP. As a result, therapists can adjust the treatment

specifically to an individual patient, taking into account his/her capabilities and limitations. Various therapeutic methods have been shown to produce significant changes in fine and gross motor skills. In the related literature it is difficult to find studies focusing on long-term effects of therapies applied to children with CP. The current findings show that at the end of the 6-month therapy, the children's functional performance was improved, which was reflected by all the outcome measures. However, the acquired skills were not retained after the 2-month period with no therapy, as shown by the measurements performed using GMFM, PEDI, Box and Block, and Index Barthel. Hence, to decrease a risk of regression in their functional performance it is necessary to reinforce effects of therapy by ensuring continuous and systematic rehabilitation of children with CP. On the other hand, the assessments carried out using SI tests showed that the effects of the 6-month therapy were sustained at a similar level 2 months after the program ended. This suggests that therapy focusing on sensory functions such as tactile perception, somatognosis, and spatial orientation could be included as a permanent component of rehabilitation programs in day care centers providing treatments to children with CP.

There are certain limitations of the study. Considering that the study sample was based on the population of a specific educational center that works with a certain rehabilitation technique and that the participants had a specific type of CP (ie, spastic diplegia CP), these findings cannot be easily applied to other settings and do not represent all individuals with CP. Therefore, further research concerning other types of CP and rehabilitation techniques are required. In accordance with the design of the current study, there was no control group, which would have enabled a comparative analysis. This limitation is linked with the fact that all children in this particular day care center receive rehabilitation, so we could not select a control group of subjects receiving no therapy. We are aware that this is a considerable weakness of the study, but, to partly compensate for this limitation, we performed the third examination (a follow-up) 2 months after therapy, which enabled assessment of the long-term effects of rehabilitation. It is necessary to continue research focusing on assessment of functional performance relative to the duration, type, and intensity of therapy provided to children with CP which would take into account a control group. The small sample size is the next limitation of this study. However, the sample size calculation process that was carried out showed that our sample of participants was adequately powered for the feasibility study. Moreover, the present study was continued for a relatively short time (8 months only); further research should be designed to monitor therapy effects during a longer period of time.

Despite these limitations, the study also presents some strengths. This was an observational study focusing on a

uniform group of subjects presenting similar characteristics at baseline. Furthermore, all the study participants received treatment from the same physiotherapist and were then assessed by one examiner who performed 3 measurements at different time points to assess the long-term effects of the therapy. Rater calibration was performed and showed good reliability of the measurements performed by the examiner. Furthermore, the rehabilitation program applied in the current study was based on multi-targeted approach combining NDT/Bobath, PNF, and SI therapies (detailed description of the therapies is included in **Table 2**). All the above factors suggest that the outcome of this study can be applied to other settings. As for the functional implications of this study, the findings may be of importance for clinical practice as they support the evidence showing that a lack of systematic therapy provided to children with CP adversely affects their functional capacities, and this fact should be taken into account by those designing therapeutic programs in facilities providing treatment to this population of children.

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## Conclusions

Considering the limitations of the present study, the following conclusions can be made. Immediately after the 6-month therapy program the children with CP showed significant improvement in manual, motor, and sensory capacities and in essential as well as complex activities of daily living. Later, following a 2-month period with no therapy, the children's functional performance deteriorated significantly as reflected by all the measures, except for the sensory capacities: tactile perception and spatial orientation. This suggests that therapy focusing on functional performance could be included as a permanent component of rehabilitation programs in day care centers providing treatments to children with CP. As regards the broader implications of this study, the findings may be of importance for clinical practice since they show it is necessary to provide continuous and systematic therapy to children with CP in order to reduce a risk of regression in their functional capacities. This information may be helpful for therapists working in day care facilities, and for parents/guardians planning effective therapy of children with CP, and it should be taken into account by those designing therapeutic programs in facilities providing treatment to this population of children. Effectiveness of the 6-month therapy program in children with CP was not related to their age, sex, or comorbidities.

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