

## Manual ability and manual dexterity in children with cerebral palsy

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### Abstract

**Introduction:** Manual ability and performance of dexterity tasks require both gross and fine hand motions and coordination. The aim of this study was to determine the level of manual dexterity (capacity) and investigate its relationship with manual ability (performance) in children with cerebral palsy.

**Method:** This study was designed as a cross-sectional study of 30 children with cerebral palsy (aged 8-15 years). In order to assess gross manual dexterity the Box and Block Test was used. Manual ability was assessed according to Manual Ability Classification System (MACS).

**Results:** A relationship between the level of manual ability impairment and performance on manual dexterity tasks was expressed. Participants at MACS level IV demonstrated slowest times and transferred the smallest number of blocks ( $p < 0.01$ ). This study also found that correlation between Gross Motor Function Classification Scale (GMFCS) and MACS is statistically significant ( $p < 0.001$ ). All hand skills were more impaired in the non-dominant hand compared to the dominant hand but there were no statistically significant difference ( $p = 0.06$ ).

**Conclusion:** The results suggest that gross manual dexterity is a good predictor of manual abilities in children with cerebral palsy. These results provide better understanding of the relationship between manual dexterity and activity limitations and lend credibility to the use of these classification systems and assessments in order to optimize treatment planning and evaluate interventions and progress. Hippokratia 2014; 18 (4): 310-314.

**Keywords:** Cerebral palsy, gross manual dexterity, fine finger dexterity

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### Introduction

Cerebral palsy (CP) is characterized by motor dysfunction caused by non-progressive brain damage, which occurs early in life<sup>1</sup>. Various impairments could affect the child's ability to respond to environmental and socio-cultural needs, including limitations in strength, sensibility, fluency, accuracy, dexterity<sup>2-4</sup>. The limitations can affect body structure and function, as well as activity and participation domains<sup>5</sup>.

More than a half of the children, diagnosed with CP experience various upper limb problems, of different severity and heterogeneity<sup>1-7</sup>. Manual ability refers to the child's attempt to perform a particular activity. Manual ability and performance of dexterity tasks require both gross and fine hand motions and coordination. Children with CP usually have difficulties performing manual activities such as grasping, releasing or manipulating objects, which is crucial in the performance of many activities of daily life<sup>4,6-9</sup>. Hand function problems in children with CP are often associated with problems of motor control, active range of motion, grip strength and persistence of primitive grasp reflex<sup>8</sup>, but are not always correlated with manual ability impairments<sup>6,10</sup>. Moreover, manual ability and achievement in motor tasks can be influenced

by motivation and cognition<sup>1</sup>. Manual activities require the cooperation of both hands, where the dominant hand performs both fine and gross manipulations, and the non-dominant hand is used to stabilize objects<sup>11</sup>. Children with CP develop their handedness on the less affected side. Gross manual dexterity and grip strength on both hands, followed by fine finger dexterity are the strongest predictors of manual ability, while tactile pressure detection and proprioception show lowest correlation with manual ability<sup>12,13</sup>. Manual dexterity was found to be a strong predictor of functional independence in activities of daily living<sup>14,15</sup>. The limited arm function is present in all types of CP, but the characteristics of the disorder vary depending on the subtypes of CP<sup>16</sup>. Recent reviews of the relationship between upper limb impairments and functional abilities focused on activity limitations and restrictions in participation<sup>1,17-19</sup>.

The need to measure efficiency, body structure and function, activity level as well as participation outcomes effectively in children with CP is important in order to optimize treatment planning and evaluate interventions and progress<sup>11</sup>. Previous studies on children with CP had a tendency to focus on analyzing their gross motor functions. However, as reviewed by some authors, many

reliable and valid assessment tools became available to measure functional skills in children with CP<sup>20,21</sup>. This shift in focus and increasing interest in manual ability and dexterity of children diagnosed with CP improved the understanding of the condition and facilitated the design of appropriate treatments<sup>22</sup>.

The general purpose of this study was to apply instruments that were not applied in this area and thus contribute to the assessment of manual ability and dexterity of children diagnosed with CP. A more specific aim of the study was to determine the level of manual dexterity (capacity) and research its relationship with manual ability (performance) in children with CP.

## Materials and Methods

### Participants

The study population consisted of 30 children with congenital CP aged 8-15 years [mean 11.95 standard deviation (SD) 2.56], included 17 male (56.7%) and 13 female (43.3%) participants. The sample was comprised of CP of 12 hemiparetic children (40%), 6 diparetic children (20%) and 12 quadriparetic children (40%). Nineteen children (63.3%) were right handed, 9 left handed (30%) and two ambidextrous (6.7%). Intellectual disability was present in 5 participants (16.7%).

All participants were diagnosed with spastic CP, and were able to understand the test instructions. The participants were recruited from two schools for students with special needs. The exclusion criteria were other diagnosis of CP, insufficient cooperation, surgery interventions on upper limb, and botulinum toxin injections administered in the last 6 months. The study was approved by the School's Ethical Committee. Informed consent was obtained from children's parents or guardians as well as school administrators, who were informed about the aim and course of this research.

### Instruments

Motor skills were assessed using the Gross Motor Function Classification Scale (GMFCS), while manual abilities were assessed with the Manual Ability Classification System (MACS). The Box and Blocks test (BBT) was used to study manual dexterity. GMFCS and MACS were completed by the examiners who are experts in the field of special education and rehabilitation, based on their observation of the child's behaviour.

The GMFCS is a five level classification system used to determine which level best represents the child's present abilities and limitations in gross motor function. Level I, includes children with minimal or no disability, while level V, includes children who are totally depend-

ent on external assistance for mobility<sup>23</sup>.

The MACS, like the GMFCS, is a five level system, where level I includes children with minor limitations, while children with severe functional limitations are to be found at level IV and V<sup>24,25</sup>. Gross manual dexterity was measured using the BBT according to the procedure described by Mathiowetz<sup>26</sup>. The equipment for the BBT is consisted of a wooden box size 53.7 x 25.4 cm divided into two compartments by a partition, 15.2 cm in height. Participants were instructed to grasp the blocks (diameter of 2.5 cm) individually from one compartment of the box, transport them over the partition, and release them into the opposite compartment of the box as quickly as possible within 60 seconds. They performed the test once with each hand, starting with the dominant hand.

### Statistical analysis

Descriptive statistics were used to report general characteristics of the sample. The non-parametric Kruskal Wallis analysis of variance was used to compare more than two groups with multiple comparisons of ranks as a post hoc test. The relationship between manual dexterity and MACS levels was analyzed using the Spearman rank order correlation, with correlation coefficients >0.70 considered as high, 0.50-0.70 as good, 0.30-0.50 as fair and <0.30 as weak or no association. Statistical significance was defined as a p-value of <0.05<sup>27</sup>.

## Results

The largest number of children was classified at GMFCS level II and MACS level III. Fourteen children (46.7%) of the total sample were classified at GMFCS level II while 11 children (36.7%) were classified at MACS level III. Based on the type of CP, most children were classified at the highest levels (IV, V) in both classifications and they were diagnosed with quadripareisis.

In order to measure manual dexterity, the Box and Block Test was used. Firstly, the performance of these tasks was observed depending on whether they were carried out using the dominant or the non-dominant hand. Wilcoxon matched pairs test, which was used for comparison, did not show statistically significant difference ( $p=0.06$ ) in the performance of the tasks regardless whether the measurements were made on the dominant or non-dominant hand (Table 1). The results of the task showed a clear trend toward significance on the gross manual dexterity task (mean value was 20.75 on the dominant hand and 16.23 on the non-dominant hand).

The Kruskal Wallis test was used to analyze performance on manual dexterity tasks related to CP subgroups and MACS levels (Table 2). Multiple comparisons of

**Table 1:** Performance on the dominant and non-dominant hand on manual dexterity test.

	n	Mean	Std. Deviation	Min	Max	Z	p
GMD dominant hand	24	20.75	10.48	6	39	-2.74	0.06
GMD non-dominant hand	22	16.23	10.93	2	36		

GMD: gross manual dexterity.

ranks as a post hoc test showed statistically significant difference in gross manual dexterity ( $p < 0.00$ ) between hemiparetic and diparetic subgroups, as well as between hemiparetic and quadriparetic subgroups, with achieve-

searchers who reported that children with CP show limitations in performing activities of daily living<sup>28-30</sup>.

The study concurs with similar studies, where quadriparetic children are presented with considerably impaired

**Table 2:** Distribution of achievements on manual dexterity tests across cerebral palsy subgroups and manual ability classification system (MASC) levels.

		Mean	df	Mean Rank	Chi-Square	p
CP subgroups						
GMD	Hemiparetic	29.90	2	18.60	12.92	0.00
	Diparetic	15.67	2	8.42		
	Quadriparetic	13.13	2	7.94		
MASC levels						
GMD	1	31.33	3	19.00	10.26	0.01
	2	19.40	3	15.00		
	3	14.67	3	10.50		
	4	6.80	3	5.30		

CP: cerebral palsy, MACS: manual ability classification system, GMD: gross manual dexterity, df: degrees of freedom.

ment in hemiparetic subgroup higher than in the other two. Same statistical test was used to analyze performance on manual dexterity task related to MACS levels. The participants who were classified at MACS level V were not able to perform these tasks, while the participants at MACS level IV recorded slowest and transferred the smallest number of blocks. Multiple comparisons of ranks as a post hoc test showed statistically significant difference in gross manual dexterity performance across MACS levels I-IV ( $p < 0.01$ ).

Correlation between GMFCS and MACS in the sample was high (Spearman  $r = 0.73$ ,  $p < 0.01$ ). In terms of CP subgroups, the most pronounced correlation between these tests was noted in the group of children with quadriparetic (Spearman  $r = 0.83$ ,  $p < 0.01$ ), followed by the group of children with hemiparesis (Spearman  $r = 0.63$ ,  $p < 0.03$ ). Conversely, in the group of children with diparesis, the correlation was not statistically significant (Spearman  $r = 0.48$ ,  $p > 0.05$ ), which may be explained by the type of impairment where muscle stiffness is mainly in the legs, and small sample size ( $n = 6$ ) in this subgroup.

Manual abilities represented through MACS significantly but moderately correlated with gross manual dexterity ( $r = -0.467$ ,  $p < 0.05$ ). At the same time GMFCS levels significantly correlated with gross manual dexterity ( $r = -0.654$ ,  $p < 0.01$ ).

## Discussion

In this study participants' manual ability was initially categorized by assessing their performance when handling objects in daily life and their movement ability by measuring gross motor functions. Based on the results obtained using the MACS it can be observed that 73.33% participants required assistance in preparation and/or adaptation to the activity, otherwise they experienced limitations when performing even the simplest activities. These results are consistent with the findings of other re-

searchers who reported that children with CP show limitations in performing activities of daily living<sup>28-30</sup>. The results revealed that the participants with quadriparetic recorded slowest and transferred the smallest number of blocks.

The degree of deformity, impairments, and motor control affected the hand function and performance of gross motor activities of CP participants<sup>2</sup>. Those with pronounced deformities, contractures and reduced motor control reduced capacity and performance in carrying out everyday activities. In more than 30% of hemiparetic children impairments are present on non-paretic dominant hand<sup>13</sup>. Therefore children with CP had more problems when performing daily manual activities than gross motor abilities. These findings are in line with previous studies<sup>9,25,32</sup>.

The correlation values across the CP subgroups were different, with the most significant correlation reported in quadriparetic children. The degree of deformity, impairments, body conditions, cognition and motivation could effect on motor skills in children with CP<sup>6,34-38</sup>. These findings imply that GMFCS and MACS classifications work well together. The data obtained using these two classification systems, provides for a comprehensive overview of the child's capabilities, facilitating the design of the treatment plan and monitoring.

While it is true that gross motor functions are important predictors of daily living activity in children with CP<sup>39</sup>, they are not the only predictive instruments. In the present study, manual dexterity was explored with respect to CP subgroups and its relationship with manual abilities. The results emphasize the importance of manual dexterity as presented through gross manual dexterity.

Properly results on gross manual dexterity, in this study, could be explained by the fact that when manipulating bigger objects children use different manual strategies to perform the tasks contrary to fine finger dexterity, which requires more complex movements. These

findings lend support to previous studies and imply that training should address gross manual dexterity, finger coordination, distal muscles strength, as well as increasing bimanual skills, which can result in developing more effective movement strategies<sup>36,40</sup>.

Results were analyzed on gross manual dexterity as associated with to MACS levels. The results revealed that the participants with quadriplegia recorded slowest and transferred the smallest number of blocks, and needed extra time when tasking.

In this study gross manual dexterity was significantly but moderately correlated with MACS. These results lend support to previous studies showing that gross manual dexterity is the strongest predictor of manual ability<sup>12,13</sup>. Nevertheless, current results showed marked differences in manual dexterity depending on the level of manual ability, thus demonstrating that manual dexterity has an important impact on activity measures.

Further research is necessary in order to overcome limitations of this study, and to explore these problems on a larger sample, while taking hand impairments, training and motivation into account with the aim of providing guidelines for assessment and better planning of rehabilitation programs.

#### Limitations of the study

Since this cross-sectional study included a small sample of children with CP, the ability to generalize the results is limited. The composition and size of the sample may have had an effect on the absence of differences between the results related to the dominant and non-dominant hand. Moreover, the smallest number of participants was in the diparetic group of children, where the best results in manual activities can be expected. The disparity might be further explained by the fact that hemiparetic children experience problems in the non-dominant hand as well. No other different assessment tool results were used.

#### Conclusions

This study investigated the relationship between manual abilities and manual dexterity in children with CP. The results showed that gross manual dexterity was the best predictor of manual abilities in children with CP. Moreover, children at a lower MACS level had more success in manual dexterity tasks. In particular, manual activities were determined by the degree of impairment. These results provide a better understanding of the relationship between manual dexterity and activity limitations and lend credibility to the usage of these classification systems and assessments to optimize treatment planning and evaluate interventions and progress.

#### Conflict of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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