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ORIGINAL PAPER

Grzegorz Przysada [1,2(ABCDEF)], Agnieszka Guzik [1(BCDE)], Andżelina Wolan-Nieroda [1(BCDE)], Magdalena Przybyło [1(BCD)], Mariusz Drużbicki [1,2(DF)], Artur Mazur [1,2(EF)]

Assessment of manual abilities in children with infantile cerebral palsy

[1] Institute of Physiotherapy, Medical Department, University of Rzeszow, Rzeszów, Poland
[2] Clinical Department of Rehabilitation in the Regional Hospital no. 2, Rzeszów, Poland

ABSTRACT

Introduction. Cerebral palsy (CP) is a problem presenting multiple issues and the prevalence of this condition is quite significant. CP risk factors are mainly observed in prematurely born children as well as those affected by complications around the time of birth or during the period of mother's pregnancy. Quite frequently CP is manifested by abnormal muscle tone, contractures and deformities, and consequently impaired fine and gross motor functions.

Aim. The study was designed to examine the level of hand function, i.e. fine motor skills and to investigate whether there is a correlation between development of fine motor and gross motor functions.

Material and methods. The study group included 80 children with infantile CP. In the group there were 24 cases with spastic diplegia, 36 with spastic hemiplegia, and 20 with bilateral hemiplegia. During the study the children performed Box and Blocks test, and their parents filled in Manual Ability Classification System (MACS) describing the level of fine motor function development in their children. The children were additionally asked to perform two motor tasks. The first one involved an attempt to assume position on all fours, and the other one checked the ability to assume and maintain standing position.

Results. The best scores in the conducted tests were found in children with CP taking the form of spastic diplegia, and the poorest scores in MACS, Box and Blocks test as well as in motor tasks assessing gross motor function were observed in children with bilateral hemiplegia.

Conclusion. The form of infantile CP affects the level of manual abilities. There is a correlation between the level of gross motor and fine motor functions development.

Keywords. fine motor function, gross motor function, infantile cerebral palsy, manual abilities

Introduction

According to definition, "Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication,

Corresponding author: Andżelina Wolan-Nieroda, email: aa.wolan@gmail.com

Participation of co-authors: A – Author of the concept and objectives of paper; B – collection of data; C – implementation of research; D – elaborate, analysis and interpretation of data; E – statistical analysis; F – preparation of a manuscript; G – working out the literature; H – obtaining funds

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and behavior, by epilepsy, and by secondary musculoskeletal problems".[1] As a result functioning in daily life is also impaired. Problems are visible both in fine and gross motor skills, and are reflected by intellectual capacities, thought processes, deficits in mobility as well as abnormal muscle tone.[2-4]

Severity of the problems, patterns of motor involvement, and associated deficits, such as those in communication, and intellectual abilities, as well as epilepsy vary widely from subject to subject. In the most recent four decades the incidence remains at a constant level of 2-3 cases per 1,000 live births, despite the advancements in prenatal and perinatal care.[5,6]

Manual skills are reflected by the child's success in performing a specific activity. Manual tasks reflecting dexterity require engagement of fine and gross motor skills as well as motor coordination. Children with CP usually experience difficulties in performing manual operations, such as gripping, releasing or manipulation of objects, i.e. skills of key importance in many activities of daily living. Impaired functioning of upper limbs in children with CP is frequently associated with problems connected with motor control, active range of motion, grip strength and persistence of retained reflexes.[7]

Efficient hand function determines one's ability to cope with daily duties. It enables self-reliance and independence from other people. It is also a decisive factor for how much a person can learn. Without efficient hand function, we cannot independently take care of our needs, such as having meals and drinks, body care, dressing up, writing, or having fun. From the first stages of their life, children learn to explore the world using their hands.[8] Gradually acquired skills, such as hand grip or pressure applied or released consciously and intentionally, or adaptation of hand for varied functions enable people to become independent. Hence manual dexterity is a guarantee for effective functioning from conception to passing. Its gradual and progressive improvement is the foundation for the success in daily life. Even if there are deficits in fine motor skills, they can be compensated for, once hands take over the function, e.g. by moving with the help of special devices. Manual abilities are of critical importance for the quality of performance in daily life. Therefore it is necessary to highlight the role of hand therapy in children affected by CP.[9,10]

Aim

The main aim of the research was to assess manual abilities in children with CP; the secondary purpose of the study was to answer the following questions:

1. Does the level of hand function according to Manual Ability Classification System (MACS) test depend on the type of CP?
2. Is there a relationship between the score achieved on MACS scale and the number of blocks moved in Box and Blocks test?
3. Does the type of CP affect the score in Box and Blocks test?
4. Does the age of subjects affect the score in Box and Blocks test?
5. Is there a relationship between the score on MACS scale and the ability to assume the position on all fours and to stand (assume/maintain the position)?

Material and methods

The study group consisted of 80 children with CP, receiving rehabilitation treatment Special Care Educational Facility. In this group there were 24 children with diplegia spastica (spastic diplegia), 36 with hemiplegia spastica (spastic hemiplegia) and 20 with hemiplegia bilateralis (bilateral hemiplegia). The children were divided into three age groups. The first one comprised children aged 7-8 (15% 7-year-olds and 12.5% 8-year-olds). The second group consisted of children aged 9-10 (22.5% 9-year-olds and 12.5% 10-year-olds). The third group comprised children aged 11-12 (15% 11-year-olds and 22.5% 12-year-olds). The children participating in the study performed Box and Blocks test, where they were asked to move as many wooden blocks as possible from one box to another through a special partition, in course one minute, using respectively their left or their right hand. Higher scores in this test reflected better manual abilities, in terms of fine motor function. The Box and Block Test is an easy, feasible, valid, and reliable measurement for gross manual dexterity in children.[11,12] The parents were asked to specify the level of their children's manual skills with the use of Manual Ability Classification System (MACS), a scale designed to assess fine motor skills. MACS scale specified the child's ability to use objects during important every-day activities, for instance while playing, relaxing, eating or dressing up. Lower scores achieved by children with CP on MACS scale corresponds with their greater fine motor abilities, hence Level I on MACS scale represents the highest and Level V represents the poorest manual dexterity. As an addition, the children were asked to perform two motor tasks, i.e. to assume position on all fours, and to assume and maintain standing position.

All the subjects were informed about the purpose of the study and the procedure, and the children's parents or legal guardians provided written consent for their participation in the examinations. The study protocol was approved by the Bioethics Commission at the Faculty of Medicine.

Statistical analyses were computed with Statistica 10.0 software, respectively with the use of Pearson chi-square, Kruskal-Wallis and Spearman's rank correlation coefficient. Their choice resulted from a failure to meet basic assumptions of parametric tests, i.e. goodness of fit of the examined variables with normal distribution and homogeneity of variances. Goodness of fit with normal distribu-

tion was verified with Shapiro-Wilk test and homogeneity of variances with Levene's test. A test result where $p < 0.05$ was considered to be statistically significant.

Results

Description of the study participants' sex and the types of CP

The findings of the study showed that in the examined group of 80 children there were 44 (55%) boys and 36 (45%) girls. The children had been diagnosed with three types of CP; 30% of the subjects with spastic diplegia, 45% with spastic hemiplegia, and 25% with bilateral hemiplegia.

Analysis of the scores on the MACS scale

Analysis of the scores on the MACS scale showed that MACS Level I was represented by 30% of the subjects; Level II manual abilities were found in 47.5%, Level III in 12.5% and Level IV in the remaining 10% of the children. Assessment of scores on MACS scale in relation to age showed that the children aged 7-8 and 9-10 more frequently presented with Level II manual abilities, while the oldest children in the age range of 11-12 more often than the others reached MACS Level I. This correlation was not significant statistically - p=0.3710. Conversely, analysis of the scores on MACS scale relative to the type of CP showed highly significant correlation at the level of p=0.0000 (Table 1).

Table 1. MACS in relation to the type of infantile cerebral palsy

MACS		spastic diplegia	spastic hemiplegia	bilateral hemiplegia	Total
Level I	N	12	12	0	24
	%	50.0%	33.3%	0.0%	30.0%
Level II	N	12	22	4	38
	%	50.0%	61.1%	20.0%	47.5%
Level III	N	0	2	8	10
	%	0.0%	5.6%	40.0%	12.5%
Level IV	N	0	0	8	8
	%	0.0%	0.0%	40.0%	10.0%
Total	N	24	36	20	80
	%	30.0%	45.0%	25.0%	100.0%
p		x^2=54.44 p=0.0000***			

Analysis of the scores in the Box and Blocks test

Analysis of the scores achieved by the children in the Box and Blocks test, conducted separately for the boys and the girls, for the right and the left hand and relative to age range, showed that in the specific age groups the results for the right and the left hand were very similar. In the age group of the 7-8 year-olds, the girls achieved slightly higher scores, with mildly better results for the right hand; the boys, generally with poorer results, presented with higher scores for the left side. In the case of 9-10 year-old children, better results were recorded for the boys. In this age group, both the girls and the boys were more successful in the test examining the right hand. In the group of 11-12 year-old children, the girls coped with the task more effectively. Likewise, in this group both the girls and the boys scored higher in the right hand test. Generally, the best results were observed in the children aged 7-8, slightly poorer scores were achieved by the 11-12 year olds, and the lowest by those in the age group of 9-10 (Table 2).

Table 2. Score in Box and Blocks test for the right and the left hand in boys and in girls

Age [years]	boys				girls			
	Hand	mean	sd.	min-max	Hand	mean	sd.	min-max
7-8	R	24.0	11.1	10.0-38.0	R	29.4	12.6	10.0-42.0
	L	24.5	8.0	12.0-36.0	L	28.6	14.7	3.0-43.0
9-10	R	22.1	13.0	3.0-43.0	R	18.2	12.8	2.0-33.0
	L	19.5	9.2	2.0-34.0	L	13.2	11.5	0.0-27.0
11-12	R	23.0	11.6	7.0-42.0	R	25.7	14.7	3.0-41.0
	L	18.9	11.1	4.0-38.0	L	25.0	16.6	1.0-49.0

Statistical analysis based on Kruskal-Wallis test confirmed very high significance of the relationships, at the level of p<0.001***, between the number of blocks moved with both the right and the left hand and the type of CP in the examined children (Table 3). Hence, multiple comparison test was applied to find out which groups of children differed significantly in their performance in Box and Blocks trials. The differences in the number of moved blocks were found between the children with spastic diplegia and spastic hemiplegia versus the children with bilateral hemiplegia (successively for the right and the left hand p<0.001). No statistically significant differences were observed between the children with spastic diplegia and those with spastic hemiplegia (for the right hand p=0.5743 and for the left hand p=0.0854) – Table 4.

Table 3. Comparison of the scores for the right and the left hand acquired by children, relative to the type of infantile cerebral palsy

Right hand	(N)	mean	sd.	median	min-max
spastic diplegia	24	31.3	7.2	30.0	18.0-42.0
spastic hemiplegia	36	27.3	10.7	26.5	10.0-43.0
bilateral hemiplegia	20	7.4	4.5	7.0	2.0-15.0
p		H=42.19 p=0.0000***			
Left hand	(N)	mean	sd.	median	min-max
spastic diplegia	24	30.6	9.1	30.0	15.0-49.0
spastic hemiplegia	36	24.1	8.4	22.0	11.0-43.0
bilateral hemiplegia	20	5.1	4.4	3.5	0.0-12.0
p		H=48.17 p=0.0000***			

Table 4. Box and Blocks test – multiple group comparison

Box and Blocks test right hand	spastic diplegia	spastic hemiplegia	bilateral hemiplegia
spastic diplegia		0.5743	0.0000***
spastic hemiplegia	0.5743		0.0000***
bilateral hemiplegia	0.0000***	0.0000***	
Box and Blocks test left hand	**spastic diplegia**	**spastic hemiplegia**	**bilateral hemiplegia**
spastic diplegia		0.0854	0.0000***
spastic hemiplegia	0.0854		0.0000***
bilateral hemiplegia	0.0000***	0.0000***	

Associations between the Box and Blocks test and the MACS scale

Analysis with the use of Kruskal-Wallis test confirmed very high statistical significance at $p<0.001^{***}$ ($p=0.0000$ for the right hand and $p=0.0003$ for the left hand), of the relationship between the number of blocks moved with both the right and the left hand, versus the children's scores on the MACS scale. Given this, multiple comparisons test was applied to determine which groups of children differed significantly in their performance during Box and Blocks trials. Differences in the numbers of transferred blocks were found between the children with MACS Level I and II fine motor skills and the children with Level III and IV fine motor skills. These results were related to both the right and the left hand (Table 5). The best scores in Box and Blocks test were achieved by the children classified at MACS Level I. The poorest results in the blocks test were scored by children located at Level IV on MACS scale.

Table 5. Box and Blocks test – multiple group comparison

Box and Blocks test right hand	Level I	Level II	Level III	Level IV
Level I		0.0267*	0.0000***	0.0000***
Level II	0.0267*		0.0016**	0.0003***
Level III	0.0000***	0.0016**		1.0000
Level IV	0.0000***	0.0003***	1.0000	
Box and Blocks test left hand	**Level I**	**Level II**	**Level III**	**Level IV**
Level I		0.0603	0.0000***	0.0000***
Level II	0.0603		0.0225*	0.0009***
Level III	0.0000***	0.0225*		1.0000
Level IV	0.0000***	0.0009***	1.0000	

Relationships between the tests assessing fine and gross motor skills

Analyses were also performed to investigate the relationships between the tests assessing fine and gross motor skills in children with CP. Analysis based on Spearman's rank correlation test confirmed statistically very high correlation, at $p<0.001^{***}$, between fine motor skills in the children (MACS), and gross motor skills as reflected by the specific elements related to the ability to assume all-fours position and to assume and maintain standing position without assistance. The observed values of correlation were very strong. They achieved negative values at the level of $|R=-0.7|$. The negative orientation represents an increase in the value of one variable coinciding with a decrease in the value of the other variable. The higher the MACS Level achieved by the children, the more often they were unable to perform the task. Hence, poorer fine motor abilities in the children coincided with poorer gross motor skills – as reflected by the inability to perform the consecutive motor tasks and vice versa, the better the fine motor skills, the more successful the children were in tasks involving gross motor function.

Discussion

A number of tools designed to verify the level of fine motor skills in children affected by CP have emerged in recent years. These include the Manual Ability Classification System.[13-19] Jeevanantham et al. suggest that the MACS could be considered as a standard classification for children with cerebral palsy on the basis of manual abilities, and can be reliably used for children between 4 and 18 years.[20] In the current study the MACS was applied to assess children ranging in age from 7 to 12 years. Our findings show that in the group of children with spastic diplegia 50% achieved Level I manual abilities, which is evidence of well-developed motor function, and the remaining 50% of the subjects in this group achieved MACS Level II. In the group of children with spastic hemiplegia, 33.3% achieved Level I manual abilities, 61.1% Level II and only 5.6% of the subjects were classified at Level III on MACS scale. As for the next type of infantile CP, i.e. bilateral hemiplegia, none of the affected children achieved MACS Level I, while 40% of the children were classified at both Level III and Level IV of the scale.

Similar results were reported by Michalska et al., the poorest results were obtained by children with bilateral hemiplegia; as many as 60% of the study group were classified at Level IV and V, according to MACS scale.[21] According to a study carried out by Department of Hand Surgery in Stockholm, problems related to daily activities involving upper limbs were encountered by 80% of the children with spastic hemiplegia and 68% of the children with spastic quadriplegia.[22] A study by Mazanek suggests that poor experience related to gross motor abilities contributes to limitations in fine motor skills. Children affected by CP taking the form of bilateral hemiplegia achieve the poorest results related to both fine and gross motor functions. In MACS they are also classified at the two lowest levels existing in the scale – i.e. Level IV or V. [23] When it comes to the scores in Box and Blocks test it is possible to notice the follow-

ing relationships. Children with spastic diplegia on average scored 31.3 points in the trial with the right hand, and 30.6 points with the left hand. Again, the poorest results were found in children with bilateral hemiplegia who scored only 7.4 points with the right and 5.1 points with the left hand. Our study also shows that age does not significantly affect scores obtained in Box and Blocks test. Hence, it was observed that the results for the right and the left hand were similar in all age groups. Statistically significant differences in the number of transferred blocks were recorded between children with spastic diplegia and spastic hemiplegia, versus children with bilateral hemiplegia (successively for the right and the left hand $p<0.001^{***}$). No statistically significant differences were observed between the children with spastic diplegia and spastic hemiplegia (for the right hand $p=0.5743$ and for the left hand $p=0.0854$).

Our study has shown that in the case of right hand dominance, both the girls and the boys achieve higher scores in Box and Blocks test for the right hand. According to a study by Mathiowetz et al., children with the dominant right hand achieved better results than children with the dominant left hand. Additionally, lower precision was observed when blocks were moved with the left hand. That study also showed that with the growing age of the children their scores in Box and Blocks test were increasing.[24]

The present study has also established a relationship between the level of gross and fine motor functions development. The motor tasks examined the ability to assume all-fours position and to assume and maintain the standing position. Better classification on MACS scale corresponded with the children's greater gross motor skills.

The current findings also show a correlation between the level achieved on MACS scale and the number of blocks transferred in Box and Blocks test. A higher level in MACS classification corresponded with a smaller number of blocks transferred in Box and Blocks test. Similar results were reported by Golubović et al. who in their study assessed manual ability and manual dexterity in children with cerebral palsy. The study involved 30 children with cerebral palsy. In order to assess gross manual dexterity the Box and Block Test was used. Manual ability was assessed according to MACS scale. The researchers established there was a relationship between the level of manual ability impairment and performance on manual dexterity tasks. Participants at MACS level IV transferred the smallest number of blocks ($p<0.01$). All manual skills were more impaired in the non-dominant hand compared to the dominant hand but there were no statistically significant differences ($p=0.06$).[25] Similarly, Öhrvall et al. and Araneda et al. also demonstrated a strong association between the MACS and the Box and Block test ($p<0.05$). They observed significant differences in the performance of the children with CP between the various MACS levels and the Box and Block test ($p < 0.001$).[26,27]

These findings suggest that the MACS and the Box and Block test provide reliable information on manual abilities in children with CP. The data identified using these tools represent comprehensive overview of the child's capacities, thereby facilitating the processes of designing a treatment plan and monitoring of therapies administered. The clinical applicability of the main results is also reflected by the correlation between the level achieved on the MACS scale and the number of blocks transferred in the Box and Blocks test, since this shows that the tools can be used interchangeably in assessment of children with CP. What is more, it could theoretically be assumed that children with spastic diplegia, which mainly affects gait function, would present with manual dexterity similar to that in healthy children. However, the scores in Box and Blocks Test acquired in the present study by boys and girls representing three age groups were examined with reference to the norms for children [12,13], and it was found that the scores acquired by the subjects with spastic diplegia were nearly two times lower. These findings suggest that manual dexterity in these patients significantly differs from the norm. The limitation of the study was the fact that there was no control group consisting of healthy children; these will be included in further research.

Conclusions

The level of manual dexterity depends on the type of infantile CP. The children with spastic diplegic CP presented with the best manual skills. The poorest functional hand performance was observed in children with bilateral hemiplegia.

There is a relationship between the level achieved on MACS scale and the number of blocks transferred in Box and Blocks test. The lower the level acquired by the child in MACS classification, the greater the number of blocks moved by him/her, and the higher the level in MACS classification, the fewer the number of blocks successfully transferred in the task.

Type of infantile CP significantly impacts the score obtained in Box and Block test. The children with spastic diplegia acquired the highest scores. Similar, yet slightly lower scores were obtained by children with spastic hemiplegic CP. The poorest results were acquired by children affected by bilateral hemiplegia.

Moreover, age of children with CP does not significantly affect the scores in Box and Blocks test.

There is a correlation between the identified MACS level and selected gross motor skills. The study has shown that the ability to assume all-fours position and to assume/maintain standing position is significantly related to the quality of fine motor function development.

References

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of CP April 2006. *Dev Med Child Neurol Suppl.* 2007;109:8–14.
2. Marret S, Vanhulle C, Laquerriere A. Pathophysiology of cerebral palsy. *Handb Clin Neurol.* 2013;111:169-176.
3. Colver A, Fairhurst Ch, Pharoah P. Cerebral palsy. *Lancet.* 2014;383:1240-1249.
4. Longo M, Hankins GD. Defining cerebral palsy: pathogenesis, pathophysiology and new intervention. *Minerva Ginecol.* 2009;61(5):421-429.
5. Ryan JM, Cassidy EE, Noorduyn SG, O'Connell NE. Exercise interventions for cerebral palsy. *Cochrane Database Syst Rev.* 2017;11(6):1-9.
6. Smithers-Sheedy H, McIntyre S, Gibson C, et. Al. A special supplement: findings from the Australian Cerebral Palsy Register, birth years 1993 to 2006. A report: the definition and classification of cerebral palsy. *Dev Med Child Neurol Suppl.* 2016;58(2):5-10.
7. Tavernese E, Petrarca M, Rosellini G, et al. An innovative hybrid modular ankle-foot orthosis to tune the variable rehabilitation needs in hemiplegic cerebral palsy. *NeuroRehabilitation.* 2017;40(3):447-457.
8. Holmefur M, Krumlinde-Sundholm L, Bergström J, Eliasson AC. Longitudinal development of hand function in children with unilateral cerebral palsy. *Dev Med Child Neurol.* 2010;52(4):352-357.
9. Tükel Kavak Ş, Eliasson AC. Development of handwriting skill in children with unilateral cerebral palsy (CP). *Disabil Rehabil.* 2011;33(21-22):2084-2091.
10. Bleyenheuft Y, Gordon AM. Precision grip control, sensory impairments and their interactions in children with hemiplegic cerebral palsy: a systematic review. *Res Dev Disabil.* 2013;34(9):3014-3028.
11. Jongbloed-Pereboom M, Nijhuis-van der Sanden MW, Steenbergen B. Norm scores of the box and block test for children ages 3-10 years. *Am J Occup Ther.* 2013;67(3):312-8.
12. Mathiowetz V, Federman S, Wiemer D. Box and Block Test of Manual Dexterity: Norms for 6–19 Year Olds. *Canad J of Occup Ther.* 1985;52:241-245.
13. Silva D1, Funayama CA, Pfeifer LI. Manual Ability Classification System (MACS): reliability between therapists and parents in Brazil. *Braz J Phys Ther.* 2015;19(1):26-33.
14. Park ES, Joo JW, Kim SA, Rha DW, Jung SJ. Reliability and Validity of the Upper Limb Physician's Rating Scale in Children with Cerebral Palsy. *Yonsei Med J.* 2015; 56(1):271-276.
15. Rethlefsen SA, Ryan DD, Kay RM. Classification systems in cerebral palsy. *Orthop Clin North Am.* 2010;41(4):457-467.
16. Gunel MK, Mutlu A, Tarsuslu T, Livanelioglu A. Relationship among the Manual Ability Classification System (MACS), the Gross Motor Function Classification System (GMFCS), and the functional status (WeeFIM) in children with spastic cerebral palsy. *Eur J Pediatr.* 2009;168(4):477-485.
17. Akpinar P, Tezel CG, Eliasson AC, Icagasioglu A. Reliability and cross-cultural validation of the Turkish version of Manual Ability Classification System (MACS) for children with cerebral palsy. *Disabil Rehabil.* 2010;32(23):1910-1916.
18. Eliasson AC, Krumlinde-Sundholm L, Rösblad B, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. *Dev Med Child Neurol.* 2006;48(7):549-554.
19. Paulson A, Vargus-Adams J. Overview of Four Functional Classification Systems Commonly Used in Cerebral Palsy. *Children (Basel).* 2017;24(4):E30.
20. Jeevanantham D, Dyszuk E, Bartlett D. The Manual Ability Classification System: A Scoping Review. *Pediatr Phys Ther.* 2015;27(3):236-241.
21. Michalska A, Wendorff J, Boksa E, Wiktor P. Quality of life of children and adolescents with cerebral palsy and intellectual disability. Selected social and demographic conditionings. *Child Neurol.* 2010;21:35-44.
22. Arnen M, Eliasson AC, Nicklasson S, Sommerstein K. Hand function in cerebral palsy. *J Hand Surg Am.* 2008;33(8):1337-1347.
23. Mazanek E. Degree of motor paralysis and mental development of children with cerebral palsy. *Adv Rehabil.* 1993;7:77-81.
24. Mathiowetz V, Federman S, Wiemer D. Box and Block Test of Manual Dexterity: Norms for 6-19 Year Olds. *Can J Occup Ther.* 2013;52(2):241-245.
25. Golubović Š, Slavković S. Manual ability and manual dexterity in children with cerebral palsy. *Hippokratia.* 2014;18:310-314.
26. Öhrvall AM, Krumlinde-Sundholm L, Eliasson AC. Exploration of the relationship between the Manual Ability Classification System and hand-function measures of capacity and performance. *Disabil Rehabil.* 2013;35(11):913-918.
27. Araneda R, Ebner-Karestinos D, Paradis J, et al. Reliability and responsiveness of the Jebsen-Taylor Test of Hand Function and the Box and Block Test for children with cerebral palsy. *Dev Med Child Neurol.* 2019;in press. doi: 10.1111/dmcn.14184.