



Original Article

What do the relationships between functional classification systems of children with cerebral palsy tell us?

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Abstract. [Purpose] To examine the distribution of and relationship between the Gross Motor Function, Manual Ability, and Communication Function Classification Systems in different limbs of children with spastic cerebral palsy. We also investigated whether the four predicting variables of gender, age, manual ability, and gross motor classifications could significantly predict effective and non-effective communicator groups in communication function. [Subjects and Methods] This retrospective cross-sectional study included 327 children with a mean age of 10.13 ± 4.09 years. Classifications were performed by an experienced pediatric physiotherapist. [Results] Gross motor function levels showed a strong correlation with manual ability levels ($r_s=0.78$). Manual ability level was strongly correlated with communication function levels ($r_s=0.73$), particularly in quadriplegic children ($r_s=0.78$). Gross motor function levels were moderately correlated with communication function levels ($r_s=0.71$). Effective communicators in communication function showed more functional levels of manual ability and were determined by Gross Motor Function classifications. The variables were better at predicting ineffective communicators (91% correct) compared with effective communicators (85% correct). [Conclusion] Further studies are needed to relate these functional performance systems to the activity and participation levels as well as the quality of life, desires, and participation of the subjects.

Key words: Cerebral palsy, Classification systems, Function

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INTRODUCTION

Problems related to mobility, manual ability, and communication are common in the sensorimotor and developmental processes affecting the daily living activities of children with cerebral palsy (CP)^{1, 2)}. The Gross Motor Function Classification System (GMFCS-E&R), Manual Ability Classification System (MACS) and Communication Function Classification System (CFCS) are commonly used to classify the various functions and performances of children with CP in an inexpensive and simple manner for clinical- and research-oriented pediatric rehabilitation use³⁾.

These systems can be used by healthcare professionals as well as parents to classify the functions of children with CP regarding their activity/participation level within the International Classification of Functioning, Disability and Health (ICF) framework⁴⁻⁷⁾. GMFCS, MACS, and CFCS are used to classify gross motor function, manual ability, and communication function, respectively⁵⁻⁷⁾ and classify children with CP in a manner similar to evidence-based tools, ranging from Level I (least affected by disability) to Level V (most affected by disability)³⁾. They enable a common language to be used by

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clinicians, investigators, and families to understand the child's functional performance, set goals, and make management decisions related to ICF^{4, 7, 8}). In addition, these three classification systems have been translated into more than 15 different languages. Their validity, reliability, and a range of other attributes have been assessed by studies in various languages, contributing rapidly to increased, new and important scientific knowledge⁹⁻¹¹). A previous study investigated the relationship between these classification systems and found a moderate to strong relationship³). The hypothesis of that study was that mobility, communication, and manual ability were not related as functions, and that the location of the brain injury affected the neural structures associated with these systems³). However, the relationship between classification systems in different limbs is still unclear. Therefore the purposes of this study was to examine the distribution and relationship between GMFCS, MACS, and CFCS levels in different limbs of children with spastic CP. In addition, our second purpose was to assess whether the four predicting variables of gender, age, MACS, and GMFCS could significantly predict effective and non-effective communicator groups in CFCS. Our hypotheses were as follows: 1) All classification systems have a significant relationship with each other and 2) Age, gender, and the GMFCS and MACS classification systems can predict effective communicators of CFCS levels.

SUBJECTS AND METHODS

The participants in this study were pediatric CP patients and their parents. They had been referred to our unit for a home exercise program and family training between August 2015 and January 2016. Our clinical and research reference center accepts pediatric CP patients who have been referred from anywhere in Turkey.

The inclusion criteria were (1) a diagnosis of spastic CP and (2) age 4–18 years. The exclusion criteria were lack of a definite CP diagnosis and age less than 4 years. This study was approved by the Hacettepe University Noninterventional Clinical Research Ethics Committee (GO 15/436). Written informed consent from the families and informed assent from children was obtained after all were informed about the study.

This retrospective cross-sectional study was designed to collect the data of children with CP using the GMFCS, MACS, and CFCS classification systems⁵⁻⁷). These three systems have been routinely utilized for the physiotherapy assessment of children with CP at our unit. Children were classified as a level “best representing” their function. The child's abilities and skills were represented as two different levels for some children. In these cases, the “lowest” level was chosen for classification. To prevent potential bias during classification, each classification system was utilized by the same researcher (first author A.M.), with 17 years of experience in this field.

The following classification systems were used: 1) GMFCS-E&R was used to classify the gross motor function of children⁵). GMFCS-E&R is the expanded and revised version of GMFCS including an age band of 12–18 years. It emphasizes the World Health Organization's ICF concepts^{4, 5}). The participants were classified using the Turkish version of the GMFCS-E&R^{12, 13}); 2) MACS was used to classify the manual ability of children. MACS classifies pediatric CP patients according to how they use their hands when handling objects in various daily activities (such as playing, eating, dressing) with the physiotherapist observing the usual performances rather than the best ability⁶). MACS reports the child's level based on the participation of both hands during activity and can be used for children aged 4–18 years⁶). We used the Turkish MACS in this study¹⁴). Cultural validation of MACS was published by Akpınar P et al.¹⁵); 3) CFCS was used to classify the everyday communication performance of children with CP⁷). CFCS provides a valid and reliable classification of communication performance and activity limitations for research and clinical purposes^{7, 9}). The Turkish CFCS has been translated from the original English version and then back translated¹⁶).

SPSS 18.0 was used for statistical analyses. We calculated Spearman's correlation coefficients (r_s) for the functional classification systems GMFCS, MACS, CFCS and the various limb distributions of CP (hemiplegia, diplegia, and quadriplegia). The following Spearman's correlation coefficient strength interpretation was used: $|r| > 0.70$ strong relationship; $|r| = 0.69-0.30$ moderate relationship; and $|r| < 0.29$ weak relationship^{17, 18}). Logistic regression analysis was performed to determine whether age, gender, GMFCS, or MACS variables predicted children with effective communication in CFCS could be assessed. Statistical significance was indicated by a p value < 0.05 .

RESULTS

The study included 327 children with spastic CP (203 [62.1%] boys and 124 [37.9%] girls) with a mean age of 10.13 \pm 4.09 years. Of the 327 children, 10% had hemiplegia, 35% had diplegia, and 54% had quadriplegia. Quadriplegia cases were classified mostly as Level IV and Level V of the GMFCS and CFCS and mostly between Level III and V of MACS. Hemiplegia cases were classified mostly as Level I and II of the GMFCS and MACS and between Level I and III of CFCS. Diplegia cases were classified mostly as Level II to IV of GMFCS, Level I and II of MACS and between Level I and III of CFCS. The functional classification of children according to limb distribution of CP is presented in detail in [Table 1](#).

Spearman's correlations (r_s) between the classification level and CP limb distribution were calculated. GMFCS levels showed a strong correlation with MACS levels ($r_s = 0.78$, $p = 0.000$). The GMFCS correlation with limb distribution was moderate in quadriplegic children ($r_s = 0.68$, $p = 0.000$), diplegic children ($r_s = -0.46$, $p = 0.005$), and hemiplegic children ($r_s = -0.39$, $p = 0.000$). MACS level correlation with CFCS levels was strong in general ($r_s = 0.73$, $p = 0.000$), strong in quadriplegic children

Table 1. Functional classifications of children according to limb distributions

	Total n=327 (100%)	Hemiplegia n=34 (10%)	Diplegia n=115(35%)	Quadriplegia n=178 (54%)
GMFCS level				
I	9 (3)	6 (2)	2 (1)	1 (0)
II	59 (18)	21 (6)	37 (11)	1 (0)
III	58 (18)	2 (1)	43 (13)	13 (4)
IV	101 (31)	4 (1)	25 (8)	72 (22)
V	100 (31)	1 (0)	8 (2)	91 (28)
MACS level				
I	50 (15)	19 (6)	30 (9)	1 (0)
II	93 (28)	13 (4)	71 (22)	9 (3)
III	65 (20)	0 (0)	11 (3)	54 (17)
IV	80 (25)	1 (0)	2 (1)	77 (24)
V	39 (12)	1 (0)	1 (0)	37 (11)
CFCS level				
I	38 (12)	13 (4)	23 (7)	2 (1)
II	59 (18)	7 (2)	44 (14)	8 (2)
III	38 (12)	8 (2)	22 (7)	8 (2)
IV	115 (35)	4 (1)	19 (6)	92 (28)
V	77 (24)	2 (1)	7 (2)	68 (21)

Level I: most able; Level V: least able.

GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; CFCS: Communication Function Classification System.

Table 2. Correlation between limb distribution and classification systems

	Hemiplegia	Quadriplegia	Diplegia	GMFCS	MACS
Hemiplegia	-				
Quadriplegia	-0.37**	-			
Diplegia	-0.25**	-0.80**	-		
GMFCS	-0.39**	0.68**	-0.46**	-	
MACS	-0.35**	0.78**	-0.59**	0.78**	-
CFCS	-0.28**	0.65**	-0.50**	0.71**	0.73**

Level I: most able; Level V: least able.

GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; CFCS: Communication Function Classification System

($r_s=0.78$, $p<0.001$) and moderate in hemiplegic ($r_s=-0.35$, $p=0.000$) and diplegic children ($r_s=-0.59$, $p=0.000$). GMFCS levels were moderately correlated with CFCS levels ($r_s=0.71$, $p=0.000$); CFCS correlation with limb distribution was moderate in quadriplegic children ($r_s=0.65$, $p=0.000$), weakest in hemiplegic children ($r_s=-0.28$, $p<0.001$), and moderate in diplegic children ($r_s=-0.50$, $p=0.000$). The correlations are presented in [Table 2](#).

MACS and CFCS level cross-tabulations for each GMFCS level are shown in detail in [Table 3](#). Children with GMFCS Level IV and V were usually classified as high MACS and CFCS because of the high percentage of quadriplegic subjects (54%) in the study. There were only 3 children at level I in all classification systems.

Finally, logistic regression was used. We aimed to assess whether four variables (gender, age, MACS, and GMFCS) significantly predicted effective communicators of CFCS. CFCS subjects were divided into 2 groups. Level I–III were Group 1, “effective communicators”, and Level IV and V were Group 2, “non-effective communicators”. The assumptions of the observations being dependent and independent variables being linearly related to the logit were checked and met. When all variables were assessed together, they predicted CFCS Group 1 (effective communicators, $\chi^2=232.90$, $df=4$, $N=327$, $p<0.001$) at a significant rate. The odds ratios are presented in [Table 4](#), and predicted that effective communicators in CFCS (Group 1) had higher levels in MACS and GMFCS. In addition, gender, and age were not significant predictor variables according to the regression results and coefficients. Overall, 89% of the participants were predicted correctly. The independent/covariate variables enabled a better prediction of the subjects who could not perform effective communication (91% correct) than those with effective communication (85% correct).

Table 3. Cross-tabulations of MACS and CFCS levels within each level of GMFCS

GMFCS level I (n=9)						
	CFCS level					Row totals
MACS level	I	II	III	IV	V	
I	3	0	1	0	0	4
II	2	0	3	0	0	5
III	0	0	0	0	0	0
IV	0	0	0	0	0	0
V	0	0	0	0	0	0
Column totals	5	0	4	0	0	9
GMFCS level II (n=59)						
	CFCS level					
MACS level	I	II	III	IV	V	
I	13	8	7	2	1	31
II	7	12	7	2	0	28
III	0	0	0	0	0	0
IV	0	0	0	0	0	0
V	0	0	0	0	0	0
Column totals	20	20	14	4	1	59
GMFCS level III (n=58)						
	CFCS level					
MACS level	I	II	III	IV	V	
I	4	1	2	2	0	9
II	8	20	5	3	1	37
III	0	2	0	7	1	10
IV	0	0	0	2	0	2
V	0	0	0	0	0	0
Column totals	12	23	7	14	2	58
GMFCS level IV (n=101)						
	CFCS level					
MACS level	I	II	III	IV	V	
I	1	3	0	1	1	6
II	0	8	4	7	1	20
III	0	5	2	20	8	35
IV	0	0	3	24	8	35
V	0	0	0	2	3	5
Column totals	1	16	9	54	21	101
GMFCS level V (n=100)						
	CFCS level					
MACS level	I	II	III	IV	V	
I	0	0	0	0	0	0
II	0	0	1	2	0	3
III	0	0	2	12	6	20
IV	0	0	1	20	22	43
V	0	0	0	9	25	34
Column totals	0	0	4	43	53	100

GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; CFCS: Communication Function Classification System

Table 4. Logistic regression predicting effective communication in CFCS

Variable	B	SE	Odds ratio	p	% 95 Confidence Interval
Gender	-0.008	0.044	0.992	0.862	0.911–1.081
Age	0.296	0.363	1.345	0.415	0.660–2.739
MACS	1.362	0.245	3.906	0.000***	2.417–6.311
GMFCS	0.984	0.234	2.676	0.000***	1.692–4.231
Constant	-6.902	0.886	0.001	0.000***	

*p<0.05 **p<0.01 ***p<0.001

B: Beta Regression coefficient; SE: Standard Error; GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; CFCS: Communication Function Classification System

DISCUSSION

Three functional classification systems are currently widely used by clinicians and researchers to classify the gross motor, manual ability, and communication function performances of children with CP. In addition, families can classify their children reliably, using the same systems as professionals, enabling the practical measurement of these children.

The results of this study confirmed both of our hypotheses by demonstrating that the three classification systems had a moderate-strong correlation with each other and different limb distributions of children with CP. An interesting result was that the effective communication group (Level I, II and III of CFCS) was predicted by MACS and GMFCS. Using all the classification systems together was reported to provide a better overview of the daily functioning of children with CP³. Although each classification system measures different functional aspects in children with CP, they all contribute to determining the function of children with CP in terms of ICF. Previous studies reported that none of the correlation coefficients of the classification systems indicated a very strong relationship, as observed in our study^{3, 19}. The use of a single system is inadequate for describing the functional level of children with CP. Our second hypothesis was that effective and non-effective communicators could be predicted by age, gender, MACS, and GMFCS. Prediction of non-effective communicators of CFCS was better with Level IV and V of GMFCS and MACS (91% correct). In addition, the independent/covariate variables were 85% correct in the prediction of those subjects with the ability to communicate effectively.

Concordance across the levels of GMFCS, MACS, and CFCS was not expected as they are independently created and validated systems. Levels I and V would be expected to show the highest concordance as they represent the most and least functional performance, respectively. In a previous similar study, the classification level was the same in all three scales in 16% of the total number of subjects (n=222)³. A possible explanation for the high rate of 20% of children in the same classification level in our study might be the high number of participants as well as the fact that 54% of the children were in the quadriplegic group, mostly in level IV and V of the classification systems.

In a study by van der Zwart, CFCS and GMFCS were moderately correlated¹⁰. In addition, the communication performance was strongly correlated with the level of spoken comprehension and methods of communication. They concluded that the method of communication, such as verbal and nonverbal communication and the level of spoken language of a child with CP, were most strongly related to everyday communication performance¹⁰. Our study did not investigate this relationship.

Speech disorders are more common in dyskinetic CP^{20, 21}. Speech difficulties are also more often observed in children with spastic CP than in children with severe motor impairment. Therefore, the most severe speech difficulty in children with quadriplegia mostly existed in those in communication Level IV and V and GMFCS and MACS Level IV and V. This is due to the nature of the disability where quadriplegic children with four affected extremities have severe problems in all performances.

In a previous study of 222 children with CP, a strong or moderate correlation was found between the three functional classification systems³, and the correlation coefficients in our study were similar. In quadriplegic CP, the four extremities and the trunk are involved, and the GMFCS and MACS correlation was therefore found to be strong. This correlation is weaker in diplegic CP as the upper extremities are less involved compared to the lower extremities in quadriplegic CP. However, the lowest correlation between GMFCS, MACS, and CFCS was in children with hemiplegic CP in our study.

Hidecker et al. stated that it was usually not possible to predict a child's classification in two systems when the information was known for a single system, and hypothesized that a single system would be inadequate to describe the functional level of these children by the other systems³. We therefore tried to determine whether variables such as gender, age, MACS, and GMFCS predicted effective communication of the child. GMFCS, MACS, and CFCS measure the performance of children in a similar way within the concept of the ICF framework. Although we do not think that one classification system will replace the others, we wondered whether communication could be predicted with the other classification systems and found interesting results. Those subjects who were effective communicators in CFCS (Group 1) had more functional levels of MACS and GMFCS. Overall, 89% of the predictions were correct. The variables were better at predicting ineffective communicators (91% correct) than effective communicators (85% correct).

Motor functional classification systems can be used easily in classifying children with different limb distribution of CP. Communication function could be predicted with the other classification systems, gross motor and manual ability classification systems in children with CP. A limitation of the study was that we only included patients with the spastic type of CP. We do not know how the distributions, correlations, and predictions of these classification systems will differ in other types of CP such as dyskinetic and ataxic CP. Further studies are needed to relate these functional performance systems to the activity and participation levels as well as the quality of life, desires, and participation of the subjects. Additional research is also needed to understand the reasons for differing judgments of functional levels in GMFCS, MACS, and/or CFCS between parents and professionals in children with CP.

Conflict of interest

The authors report no declarations of interest.

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