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ORIGINAL PAPER

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

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Abstract The aim of this study was to investigate the relationship among functional classification systems, the Manual Ability Classification System (MACS), the Gross Motor Function Classification System (GMFCS), and the functional status (WeeFIM) in children with spastic cerebral palsy (CP). One hundred and eighty-five children with spastic CP (101 males, 84 females), 65 (35.1%) diparetic, 60 (32.4%) quadriparetic, and 60 (32.4%) hemiparetic children, ranging from 4 to 15 years of age with a median age of 7 years, were included in the study. The children were classified according to the GMFCS for their motor function and according to the MACS for the functioning of their hands when handling objects in daily activities. The functional status and performance were assessed by using the Functional Independence Measure of Children (WeeFIM). A good correlation between the GMFCS and MACS was found in all children (r=0.735, p<0.01). There was also a correlation between the GMFCS and WeeFIM subscales according to subtypes and all parameters were correlated at the level of p<0.01, the same as the MACS. There was no difference in the MACS scores among the age groups of 4–7, 8–11, and 12–15 years (p> 0.05). The use of both the GMFCS and MACS in practice and in research areas will provide an easy, practical, and simple classification of the functional status of children with CP. The adaptation of both of these scales and WeeFIM and using these scales together give the opportunity for a detailed analysis of the functional level of children with spastic CP and reflect the differences between clinical types of CP.

Keywords Cerebral palsy · WeeFIM · GMFCS · MACS · Rehabilitation

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Introduction

Cerebral palsy (CP) describes a group of disorders in the development of movement and posture, causing activity limitation which is attributed to non-progressive disturbances that occur in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behavior, and/or by a seizure disorder [4]. CP is the most common physical disability in childhood [11].

Recent studies on the rehabilitation of children with CP have focused on increasing functionality in their daily activities [14]. Therefore, the functional levels and abilities of these children have gained more importance in recent times [15]. In addition, the difference in functionality according to different types of CP should be taken into consideration.

The evaluation and implementation of an early and continuous rehabilitation of a child with CP requires a multidisciplinary approach with a team of professionals comprising of a pediatrician, a pediatric neurologist, an orthopedic surgeon, a physician, an occupational therapist, a pediatric physiotherapist, a child psychologist, and a social worker. The assessment is necessary to confirm the diagnosis, determine the cause, and assess motor function and associated problems [2, 13].

Outcome tools are used for patients with CP to measure functional performance as a baseline descriptive assessment, to select treatment goals, and to evaluate outcomes [19]. It is a growing interest in research areas to develop and use reliable, valid, and standardized tools as outcome measures and their relationship with each other for an evidence-based research [20].

The classification systems are meant to discriminate and categorize rather than “assess” [8]. The Gross Motor Function Classification System (GMFCS) classifies the child’s movement ability and The Manual Ability Classification System (MACS) represents the child’s manual ability. Both are easily applied, simple, and quick classifications which may be performed by a therapist, the family, or a related person, and provide information about the functional level of the child with CP [17]. The GMFCS is a common classification system and is an evidence-based classification tool of five levels ranging from level I, which includes children with minimal or no disability with respect to community mobility, to level V, which includes children who are totally dependent on external assistance for mobility [24]. The GMFCS has been rapidly accepted into clinical practice and research [16], and has been shown to be related directly to restrictions in activity and participation [5]. Since the time from which the GMFCS was first developed, research has required the development of a new classification tool for the upper extremity classification and to answer the question of the manual ability of the children. In order to achieve this, the MACS was developed by Elliason et al. in 2006 [9]. The MACS provides a new perspective for classifying the manual ability of children and adolescents with CP when they are handling objects in daily activities. A few recent studies on the MACS have demonstrated that it is a valid and reliable classification tool, although it has not been as widely used as much as the GMFCS to date. As judged by the parents of children with CP and health professionals, the MACS is based on a valid construct. The classification is based on observing activities, and assigns a single “level” for the collaborative use of both hands when handling objects in daily life [3]. The structure of the MACS was purposely modeled on the GMFCS in that the distinctions among the levels are intended to be clinically meaningful [10]. The focus is on manual ability, as defined in the International Classification of Functioning, Disability and Health (ICF) [27]. It has its starting point in the upper limb function, but is also influenced by environmental, personal, and contextual factors [23]. The focus of the MACS is on determining which level best represents the child’s ability to handle objects and their need for assistance or adaptations to perform manual tasks in everyday life, such as at home, school, and community settings [3]. A child’s motivation and cognitive ability influence his/her ability to handle objects and, thereby, their MACS level. Similar to the GMFCS, the MACS will enable families, clinicians, policy makers, and researchers to communicate clearly with each other and will facilitate goal setting in clinical practice. Researchers will be able to match children according to the MACS level, and to evaluate the various interventions designed to improve hand function. The MACS researchers inform that “assessment” implies a systematic exploration of the details of, in this case, manual ability, whereas the “classification” is a simple, albeit crude, process of sorting people (reliably or consistently) into mutually exclusive and collectively exhaustive categories that are thought to have meaning (validity). If different standardized tasks were added as examples, there is a high risk that the classification would evolve into a test, something that the MACS was not intended to do [9].

It seems that the GMFCS representing gross motor function and the MACS representing manual ability in children with CP are not only peer outcome measures, but they also may fulfill each other for a total and whole classification of children with CP [18]. Both the MACS and GMFCS explicitly take as their perspective the child’s usual performance at home, school, and community settings.

Daily routine activities are one of the most important activities in the lives of children with CP who have many difficulties in performing due to tone abnormalities, motor disorders, muscle weakness, upper extremity dysfunction, and many other factors [26]. The Functional Independence Measure of Children (WeeFIM), which was developed from the Functional Independence Measure (FIM), is one of the most commonly used methods for the pediatric functional evaluation of daily living activities. Recent studies have demonstrated the reliability and validity of the WeeFIM for both children with disability and healthy children, emphasizing it to be an excellent evaluation method [21].

As function is described so well by the GMFCS and MACS, we think that the GMFCS and MACS have a close relation with each other, as well as with functional measurements. A few studies have been published investigating the relation between the MACS and GMFCS and their relation with functional status. This study was based on the spastic type of CP and the purposes were to analyze the agreement of the GMFCS and MACS in children with CP, and to answer if these two classification systems indicate the difference among diplegic, hemiplegic, and quadriplegic CP. Therefore, we investigated the relationship among the GMFCS, MACS, and WeeFIM. In addition, this study was planned to study the MACS, suggest avenues of further research in MACS, to generalize the use of the MACS, to indicate its effectiveness in clinical practice, and to answer the question of the common use of the GMFCS and MACS.

Materials and methods

Participants

The study was performed on children with CP at the Hacettepe University's Faculty of Health Sciences, Department of Physical Therapy and Rehabilitation, between January 2005 and June 2007. The inclusion criteria were having been diagnosed with "spastic CP" by a pediatric neurologist, being in the age range of 4–18 years, and having accepted participation in the study. Informed consent was obtained from the families after they were informed about the study.

Out of 217 families, 198 accepted participation in the study. Thirteen out of 198 children were excluded from the study due to insufficient information from parents or caregivers during the measurements. Of the 13 children, eight were quadriparetic, four were diparetic, one was hemiparetic, ranging from 5 to 12 years of age, with a median age of 7 years.

The total cohort comprised of 185 children with CP ranging from 4 to 15 years of age, with a median age of 7 years. Of the subjects, 101 were male (54.6%) and 84 were female (45.4%).

The estimated cognitive levels (IQ) of the children were determined using a form which was filled in by the families of the children. The form was taken from the impairment form in the SPARCLE project. The IQ levels are defined according to ICD 10. The learning disability was defined as mild in children with an IQ level of 50 to 70 and severe if the IQ level was less than 50 [7]. The details of the form are given in Appendix 1. Characteristics and co-morbidity conditions, such as hearing loss, vision loss, speech disorders, and seizures, were obtained from the medical records and are presented in Table 1.

Sixty-five children (35.1%) with a median age of 7 years (range, 4–15 years) were diparetic, 60 children (32.4%) with a median age of 7 years (range, 4–13 years) were quadriparetic, and 60 children (32.4%) with a median age of 7 years (range, 4–12 years) were hemiparetic. The subtypes of CP were classified according to the Swedish Classification (SC) at the age of 4 years or later [12]. No difference was found among the age groups (Kruskal-Wallis test, $p>0.01$).

Instruments

The gross motor function of all patients was classified according to the GMFCS for CP by the research physiotherapist. In this standardized and validated scale, the severity of motor impairment of children with CP is classified by age into five levels. It is based on self-initiated movement, with particular emphasis on sitting and walking.

Table 1 Characteristics and accompanying co-morbidity conditions of children with cerebral palsy (CP)

Characteristic	Value
Ages (years), median (range)	7 (4–15)
Sex *N* (%)	
Female	84 (46.4)
Male	101 (54.6)
Types of spastic cerebral palsy *N* (%)	
Diparetic	65 (35.1)
Quadriparetic	60 (32.4)
Hemiparetic	60 (32.4)
Co-morbidity conditions *N* (%)	
Hearing problems	8 (4.32)
Vision problems	37 (20)
Speech disorders	79 (42.70)
Seizures, epilepsy	45 (24.32)
IQ status *N* (%)	
<50	35 (18.91)
50–70	40 (21.62)
>70	110 (59.45)

Distinctions between the five levels of motor function are made on functional limitations and the need for assistive devices. Thus, children classified as level I have the most independent motor function, while children at level V have the least [22]. The GMFCS levels of the children were determined by the same physiotherapist by means of observation and evaluation of the mobility of the children.

MACS provides a systematic method to classify how children with CP use their hands when handling objects in daily activities. The MACS is based on self-initiated manual ability, with particular emphasis on handling objects in an individual's personal space (the space immediately close to one's body, as distinct from objects that are not within reach). As a general principle, if a child's manual ability fits within a particular level, the child will probably be classified either at or above that level. Children who do not perform the functions of a particular level will almost certainly be classified below that level. Level I includes children with CP with, at most, minor limitations compared to typically developing children, and where the limitations, if any, barely influence their performance of daily life tasks. In the MACS, five levels are described. Distinctions between each pair of levels are also provided to assist in determining the level that most closely resembles a child's manual abilities. The scale is ordinal, with no intent that the distances between levels should be considered equal, or that children with CP are equally distributed across the five levels [3]. The MACS levels of the children were determined by means of observation and parent reports.

The WeeFIM instrument consists of six subsets with a total of 18 measurement items. The subsets are categorized as self-care (six items), sphincter control (two items),

Table 2 Distribution between levels of gross motor function (GMFCS) and manual ability (MACS) among 185 children with spastic CP

GMFCS		MACS levels					*N*
Levels		1	2	3	4	5	
1	*n*	39	23	2	0	0	64
	% of *N*	21.1%	12.4%	1.1%	0%	0%	34.6%
2	*n*	13	10	4	0	0	27
	% of *N*	7.0%	5.4%	2.2%	0%	0%	14.6%
3	*n*	12	17	9	0	0	38
	% of *N*	6.5%	9.2%	4.9%	0%	0%	20.5%
4	*n*	4	8	10	13	0	35
	% of *N*	2.2%	4.3%	5.4%	7.0%	0%	18.9%
5	*n*	0	0	1	9	11	21
	% of *N*	0%	0%	0.5%	4.9%	5.9%	11.4%
N		68	58	26	22	11	185
% of *N*		36.8%	31.4%	14.1%	11.9%	5.9%	100.0%

transfers (three items), locomotion (two items), communication (two items), and social cognition (three items). Each measurement item of the subsets is scored on a scale of 1–7, where 1 indicates total assistance and 7 shows complete independence. The minimum total score is 18 (total dependence in all skills) and the maximum score is 126 (complete independence in all skills) [21]. The WeeFIM was performed by the direct observation of the same physiotherapist and using the interviews with the caregivers, who were mostly the mothers of the children.

The GMFCS level and the MACS level were classified by the same pediatric physiotherapist according to the available manuals for the GMFCS and MACS (Appendix 2) [3, 22].

Data analyses

The statistical analysis was done with SPSS v13.01. *p*-values less than 0.05 were considered to be statistically significant. The relation among the MACS, GMFCS, and WeeFIM subset scores were analyzed with the Spearman correlation test. The Kruskal-Wallis test was used to determine if there were differences among the age groups. Differences in the GMFCS and MACS among hemiplegic, quadriparetic, and diplegic groups were examined by the Chi-square test. When data failed to meet any of the underlying assumptions necessary for obtaining reliable results, we used the standard asymptotic Monte Carlo method. The overall agreement between the GMFCS and MACS was analyzed using the non-weighted Kappa statistics. According to Altman, the Kappa value is to be interpreted as follows: <0.20 as poor agreement, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as good, and >0.80 as very good agreement [1, 6].

Results

The distribution between the levels of gross motor function (GMFCS) and manual ability (MACS) for all cases is shown in Table 2.

The results of the GMFCS, MACS, and WeeFIM according to the subtypes of CP are presented in Table 3.

Table 3 Distribution of age, GMFCS levels, MACS levels, and WeeFIM subset scores and total WeeFIM scores in relation to CP subtypes

	MACS levels						
	I	II	III	IV	V	Total	
Hemiparetic CP	26	27	7	-	-	60	
Diparetic CP	42	21	2	-	-	65	
Quadriparetic CP	-	10	17	22	11	60	
Total	68	58	26	22	11	185	
	GMFCS levels						
	I	II	III	IV	V	Total	
Hemiparetic CP	47	9	2	2	-	60	
Diparetic CP	17	18	23	7	-	65	
Quadriparetic CP	-	-	13	26	21	60	
Total	64	27	38	35	21	185	
	WeeFIM subset scores						
	Self-care	Transfers	Locomotion	Sphincter control	Communication	Social cognition	WeeFIM total scores
	Median (range)	Median (range)	Median (range)	Median (range)	Median (range)	Median (range)	Median (range)
Hemiparetic CP	36 (11–42)	18 (8–26)	15 (10–26)	14 (2–35)	10 (6–14)	21 (9–21)	117 (11–120)
Diparetic CP	32 (15–48)	15 (4–26)	10 (13–35)	14 (2–16)	14 (4–14)	20 (6–21)	96 (46–126)
Quadriparetic CP	11 (6–39)	4 (3–20)	4 (3–28)	6 (2–14)	8 (2–14)	9 (3–21)	42 (18–117)

In diparetic children with CP, 16 out of 65 children (24.6%) could walk in all environments and climb stairs (GMFCS I), as well as handling objects easily (MACS I). In the hemiparetic group, 23 out of 60 children (38.3%) were in level I of the GMFCS and MACS. In the quadriparetic group, no child was classified to be in level I of the GMFCS and MACS, six children (10%) were in GMFCS III and MACS II. Children with quadriparetic CP had the minimum scores in the overall WeeFIM scores and those with hemiparetic CP had the maximum scores (145.85±29.13 and 57.58±26.95, respectively) (Table 3).

All clinical subtypes in the distribution of the MACS and GMFCS levels had consistency among each other ($p<0.05$) (Table 4).

The overall agreement between the GMFCS and MACS was fair (Kappa value 0.28, 95% confidence interval 0.23–0.35).

Correlations between GMFCS and MACS

The correlation value was found to be $r=0.735$, $p<0.01$ for all 185 children. The correlation values of the groups were $r=0.290$, $p<0.05$ in hemiparetic children; $r=0.469$, $p<0.01$ in diparetic children; and $r=0.764$, $p<0.01$ in quadriparetic children.

Table 4 Correlation of GMFCS and MACS levels in relation to CP subtypes

Hemiparetic CP		MACS levels					χ^2	*p*-value
		I	II		III	Total		
GMFCS levels	I	23	22		2	47		
	II	-	5		4	9		
	III	1	-		1	2	21.05	0.002*
	IV	2	-		-	2		
Total		26	27		7	60		
Diparetic CP		MACS levels						
		I	II		III	Total	χ^2	*p*-value
GMFCS levels	I	16	1		-	17		
	II	13	5		-	18	15.75	0.015**
	III	11	11		1	23		
	IV	2	4		1	7		
Total		42	21		2	65		
Quadriparetic CP		MACS levels						
		II	III	IV	V	Total	χ^2	*p*-value
GMFCS levels	III	6	7	-	-	13		
	IV	4	9	13	-	26	44.55	0.000*
	V	-	1	9	11	21		
Total		10	17	22	11	60		

*Significant difference ($p<0.01$)
**Significant difference ($p<0.05$)
χ^2 test was used to determine the difference

Correlations among MACS, GMFCS, and WeeFIM

The MACS had $r=-0.780$, $p<0.01$ correlation with the self-care section of the WeeFIM; $r=-0.713$, $p<0.01$ with mobility; $r=-0.707$, $p<0.01$ with locomotion; $r=-0.565$, $p<0.01$ with communication; and $r=-0.621$, $p<0.01$ in the social section in all 185 children, while the GMFCS had $r=-0.824$, $p<0.01$; $r=-0.883$, $p<0.01$; $r=-0.907$, $p<0.05$; $r=-0.571$, $p<0.01$; and $r=-0.629$, $p<0.01$ with the respective sections of the WeeFIM. We investigated the subsections of the WeeFIM and MACS according to the clinical types of CP. There were significant correlations at the level of $p<0.01$ in the self-care, mobility, locomotion, communication, and social sections in diparetic, hemiparetic, and quadriparetic types, but the highest correlation was in the self-care section in the three subtypes and it was the highest in the quadriparetic type. We also examined the correlation between the GMFCS and WeeFIM subtypes according to clinical types and found that all parameters were correlated at the level of $p<0.01$, the same as the MACS. The highest correlation in the three subtypes was in locomotion, which is different from the MACS (Table 5).

Distribution of MACS levels according to age

One hundred and eighty-five children with the age range of 4–15 years were grouped into three age groups; 4–7, 8–11, and 12–15 years of age. We investigated whether their MACS levels differed from each other. As a result, no difference was found between the age groups (Monte Carlo significance, two-sided [sign test=0.459, 95% CI 446–472], $p>0.05$, Table 6).

Discussion

To our knowledge, this is the first study examining the relationship between the MACS and GMFCS with the WeeFIM in children with spastic CP. In our opinion, this paper may provide pediatricians and pediatric rehabilitation teams an introduction in how far the classification of CP has come. It may be important to try to make it more relevant to health professionals and expand why the use of the instruments improves the ability to care for children with CP.

The goal of the classifications in the assessment of children with CP is to assist in the communication between clinicians, select homogeneous groups of children for clinical research trials, facilitate the development of rating scales to assess improvement or deterioration with time, and, eventually, to better match individual children with specific therapies [25].

The GMFCS and WeeFIM are widely used in the clinical and research areas, while the MACS has recently gained

Table 5 Correlation among GMFCS, MACS, and WeeFIM subset scores and total WeeFIM scores

		Correlation between MACS and GMFCS	WeeFIM subset scores						Total WeeFIM score
			Self-care	Transfers	Locomotion	Sphincter control	Communication	Social cognition	
Total cases (N=185)	MACS	0.735**	−0.780**	−0.713**	−0.707**	−0.490**	−0.565**	−0.621**	−0.735**
	GMFCS		−0.824**	−0.883**	−0.907**	−0.567**	−0.571**	−0.629**	−0.846**
Hemiparetic CP (N=60)	MACS	0.290*	−0.617**	−0.272*	−0.478**	−0.522**	−0.423**	−0.437**	−0.563**
	GMFCS		−0.527**	−0.351**	−0.621**	−0.666**	−0.399**	−0.474**	−0.520**
Diparetic CP (N=65)	MACS	0.469**	−0.538**	−0.209	−0.462**	−0.480**	−0.401**	−0.309*	−0.524**
	GMFCS		−0.698**	−0.253*	−0.761**	−0.789**	−0.281*	−0.240	−0.730**
Quadriparetic CP (N=60)	MACS	0.764**	−0.647**	−0.316*	−0.629**	−0.561**	−0.502**	−0.549**	−0.635**
	GMFCS		−0.555**	−0.360**	−0.560**	−0.605**	−0.489**	−0.501**	−0.608**

*Correlation is significant at the 0.05 level (two-tailed)
**Correlation is significant at the 0.01 level (two-tailed)
Spearman's rho was used to determine the correlations

attention in the research area. Therefore, all three systems already exist and have been validated previously. The utilization of the three instruments together may provide an easy and practical definition of the levels of gross and fine motor functions of children with CP.

In our study, we initially investigated the relation between the GMFCS and MACS. Our results indicated that there was a high correlation between the GMFCS and MACS in 185 children with CP. Carnahan et al. examined the overall agreement among these classification systems by Kappa statistics and found a poor correlation between the MACS and GMFCS in 365 children with CP [6]. In our study, we also examined the overall agreement and found results similar to those of the Carnahan study. Although we found a high correlation by the Spearman rank correlation test, a poor relation was found by Kappa statistics. This may have occurred due to the characteristics of Kappa statistics that indicates the relation of the same scale in different researches [1]. Hence, the correlation coefficient represents the agreement between two different classifications.

According to our results, there was a high correlation between the GMFCS and MACS. We conclude that both scales are easily used, short, effective, and complementary in showing the motor functional classification and hand ability classification, which are important in daily living activities.

In our study, the correlations between the GMFCS and MACS in the hemiparetic, diparetic, and quadriparetic groups were found to be positive. The highest correlation was found in the quadriparetic group, while the lowest correlation was in the hemiparetic group. The high correlation of the GMFCS and MACS in quadriparetic children may be due to the effect of the trunk muscles, the upper and lower extremities, and cognitive problems. The low correlation in hemiparetic children may be due to having an alternate hand which can function normally, because these children are less affected in their manual ability and motor function.

Carnahan et al. showed that, in spastic hemiparetic children, the MACS had lower scores compared to the GMFCS, and this was contrary in diparetic children [6]. Our results were parallel to those of the Carnahan study in the distribution of the MACS and GMFCS of subtypes.

In our study, we also found that there were no quadriparetic children in level I of the GMFCS, as expected. However, 78.3% of hemiparetic and 26.2% of diparetic children were in level I of the GMFCS. Level I of the MACS included 42 children with diplegic CP and 26 children with hemiplegic CP, but no children with quadriparetic CP. This outcome is in corroboration with the philosophy of the MACS and GMFCS, which are designed to determine the level of functional ability. In addition, the other levels of the GMFCS and MACS also support this distribution. These results support the idea of the sensitiveness of the MACS and GMFCS in determining the differences in the subtypes of spastic CP.

Table 6 Correlation between the MACS and age levels in 185 children with CP

		Age levels			Total
		4–7 years*	8–11 years*	12–15 years*	
MACS levels	I	31	23	14	68
	II	38	15	5	58
	III	12	11	3	26
	IV	12	7	3	22
	V	7	3	1	11
Total		100	59	26	185

Monte Carlo significance, two-sided [sign test=0.459>0.05, 95% CI 446–472]

Our other purpose was to question whether these scales reflected the functional levels of children with CP. Therefore, we investigated the correlation among the WeeFIM, which measures functional status, and the GMFCS and MACS. We found that hemiparetic, diparetic, and quadriparetic children all had a significant correlation among the GMFCS and the MACS and the self-care, mobility, and locomotion subgroups of the WeeFIM, although they had different values. In detailed analysis, the highest correlation scores were between the self-care subgroup of the WeeFIM and MACS, while it was between locomotion subset of the WeeFIM and GMFCS. This indicates that manual ability is more effective in self-care and motor function is more effective in locomotion. The correlation between self-care and MACS was higher in quadriparetic and hemiparetic children compared to diparetic children. The MACS may be more sensitive in hemiparetic and quadriparetic children due to the fact that the upper extremities are more affected.

A child's motivation and cognitive ability influence his/her ability to handle objects and, thereby, their classification systems and functional status. If the child's motivation to perform activities is low, if they do not understand the task, or continuously ask for help and support from adults, they should be classified according to their actual performance, even if they are thought to have a higher capacity [17].

It is declared on the MACS website that the MACS can be used in different age groups, and may require some comments according to age [3]. Also, Eliasson et al. informed that it is expected that, as children get older, they will develop, learn to handle additional objects, perform new age-related activities, and handle objects as described in the MACS [9]. At the beginning of the study, we thought that the different age groups would not affect the MACS scores. We grouped 185 children into 4–7, 8–11, and 12–15 year-old age groups to investigate whether they differed from each other. Our results showed that the MACS levels did not differ according to age and the results may support the idea that the MACS can be used for children of different ages, but some interpretation is needed regarding the age of the child. In this study, in which cognitive levels are not the primary research tool, the negative correlation between the social and communication subgroups of the WeeFIM, MACS, and GMFCS may indicate that classification systems are affected by cognitive levels. The limitation of our study was that we did not carry out any comparison according to the IQ levels of the children.

It is our recommendation that further research in this area should focus on IQ levels, co-morbidity conditions, and different clinical types of CP. As a conclusion, this study reflects the difference in the subtypes of CP. Therefore, the use of both the GMFCS and MACS in practice and in research areas will provide an easy, practical, and simple classification of the functional status of children with CP. The next step in research should be to highlight the classification and perform a comparison of different clinical types of CP.

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Conflict of interest statement The authors declare that they have no conflict of interest.

Appendix 1

Estimated cognitive level of children with CP.

For the cognitive level, you can ask the parents some questions and report "*estimated cognitive level*":

Cognitive description/IQ

Has your child had an assessment of IQ in the last year or so?

If yes, what was the result? ....

1. Do you think your child learns as well as other children of a similar age?.......................*Yes/No*
2. Does your child play with and be friends with children of a similar age?...................*Yes/No*

If the answer is Yes to Questions 1 and 2, the IQ is probably >70. If not, consider the following questions:

3. Does you child have severe difficulty with learning in all aspects of development? .... *Yes/No*
4. Is your child's ability to read and understand ideas like that of a much younger child, such as one more than half of their age? .... *Yes/No*

If the answer is Yes to Questions 3 and 4, IQ is probably <50.

Otherwise the child probably falls into IQ 50–70, but this should be confirmed by expecting the answer Yes to the questions below:

5. Do you think that your child needs much more help than other children to learn things like reading and understanding ideas?............................ *Yes/No*
6. Does your child find it easier to make friends and play with younger children?................. *Yes/No*

Appendix 2

Table 7 Summary of the criteria for the GMFCS and MACS

GMFCS	MACS
Level I	
Walks without restrictions, limitations in more advanced gross motor skills	Handles objects easily and successfully
Level II	
Walks without restrictions, limitations walking outdoors and in the community	Handles most objects but with somewhat reduced quality and/or speed of achievement
Level III	
Walks with assistive mobility devices, limitations walking outdoors and in community	Handles objects with difficulty, needs help to prepare and/or modify activities
Level IV	
Self mobility with limitations, children are transported or use power mobility outdoors and in the community	Handles a limited selection of easily managed objects in adapted situations
Level V	
Self mobility is severely limited, even with use of assistive technology	Does not handle objects and has very limited ability to perform even simple actions

This table was taken from Carnahan KD, Arner M, Hägglund G (2007) Association between gross motor function (GMFCS) and manual ability (MACS) in children with cerebral palsy. A population-based study of 359 children. BMC Musculoskelet Disord 8:50

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