JRSR 11 (2024) 168-177

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

Functional Classification Systems for Children with Cerebral Palsy: An ICF-Based Approach

Azade Riyahi[1], PhD Candidate; Mehdi Rassafiani[2], PhD; Afsoon Hassani Mehraban[3]*, PhD; Malahat Akbarfahimi[1], PhD

[1]Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran
[2]School of Allied Health, Exercise and Sports Sciences, Charles Sturt University, Australia. Pediatric Neurorehabilitation Research Center, Tehran, Iran
[3]Rehabilitation Research Center, Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

Article History:
Received: 29/05/2023
Revised: 10/07/2023
Accepted: 29/07/2023

Keywords:
Cerebral palsy
Communication function classification system (CFCS)
Disability
Eating and drinking ability classification system (EDACS)
Gross motor function classification system (GMFCS)
International classification of functioning, and health (ICF)
Manual ability classification system (MACS)
Visual function classification system (VFCS)

Please cite this article as:
Riyahi A, Rassafiani M, Hassani Mehraban A, Akbarfahimi M. Functional Classification Systems for Children with Cerebral Palsy: An ICF-Based Approach. JRSR. 2024;11(3):168-177. doi: 10.30476/JRSR.2023.99023.1377.

ABSTRACT

Background: Cerebral palsy is one of the most prevalent physical disabilities in childhood. Children afflicted with this condition face a myriad of challenges and potential disabilities, which complicate treatment efforts. Integrating scales with other diagnostic instruments is increasingly crucial for accurately assessing these children and devising effective treatment strategies. This study primarily aims to review functional classification systems based on the International Classification of Functioning, Disability, and Health (ICF) for children with cerebral palsy and explore the relationships among these systems.

Methods: This study was designed to review the ICF-based functional classification systems. A comprehensive search was conducted across multiple databases, including Google Scholar, PubMed, ERIC, OVID, ProQuest, Scopus, Web of Knowledge, and OTseeker. Search terms related to cerebral palsy and various aspects of body function, activity, and participation were utilized. The search was conducted until September 2022 to gather relevant literature for analysis.

Results: The analysis of the reviewed articles revealed the existence of five valid and reliable classification systems. In most studies, the correlation among these systems was moderate. Owing to their simplicity and comprehensiveness, these classification systems have significantly impacted the depiction of the functional status of children with cerebral palsy and the quality of their care. However, additional classification systems remain needed to address other overlooked functions and complete the overall description.

Conclusion: The outcomes of this review indicated the development of classification systems for certain functions in children with cerebral palsy. In conjunction with the classifications above, creating additional new systems for overlooked functions could offer a comprehensive and integrated understanding of children with cerebral palsy's crucial functional capacities and performances.

2024© The Authors. Published by JRSR. All rights reserved.

Introduction

Developmental disabilities are pathological disorders that permanently affect children's motor, cognitive, linguistic, and social skills development. The most common motor disability is Cerebral Palsy (CP) [1]. Non-progressive disorders are the root cause of cerebral palsy, leading to limitations in daily activities [2]. Current statistics show that, on average, 2.5 out of every 1,000 people in the world are diagnosed with CP [2, 3]. Sensory, perceptual, cognitive, communication, behavioral, and secondary musculoskeletal disorders, along with hearing

*Corresponding author: Afsoon Hassani Mehraban, PhD; Rehabilitation Research Center, Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
Tel: +98 21 22227124; **Email:** mehraban.a@iums.ac.ir

and vision issues, urinary incontinence, constipation, and gastrointestinal symptoms, are among the various difficulties experienced by children with CP [1, 4]. These associated disorders can exacerbate movement disorders and may have a greater impact on children and their families than their primary movement problems [5]. Depending on the severity of their problems, children with CP exhibit less motor activity than normal children and face more challenges than their peers in school activities and social life [6].

Classification systems in healthcare are systematically created for specific purposes, addressing distinct clinical or research questions. They are developed with structures and features such as reliability and validity, demonstrating their effectiveness [7]. These systems not only facilitate communication between care providers but also assist in defining more precise populations for clinical research [8]. Given that functional disorders across various body regions significantly impede daily activities, participation, and personal and social independence, the importance of valid classification tools and scales for addressing these disorders becomes increasingly evident [9].

In general, all classifications are based on four main criteria: 1) Associated impairments, 2) Anatomical and radiological findings, 3) Causation and timing, and 4) Movement disorders: A. Nature and types of movement disorder: Under this framework, CP is categorized into three main groups—spastic, dyskinesia, and ataxic—depending on the predominant neuromotor impairments. Previously, dyskinesia was further subdivided into dystonia and chorea-athetosis [4, 7, 9]. B. Functional motor abilities: Classification based on this criterion has led to the formation of the International Classification of Functioning, Disability and Health (ICF) related to the World Health Organization (WHO). ICF is a useful framework that systematically describes the function in the general population. The main purpose of this framework as a classification system is a systematic description of health components (for example, what a person with a disease or complication does or can do). The unique advantage of this classification system is that it allows the user to record a useful history of the function and disability of people in various fields. Function classification is organized into two sections, each with two separate components. Section 1 covers function and disability that includes the following components: (a) body structures and functions, (b) activities, and (c) participation. Section 2 covers situation-related factors and includes the following components: (d) environmental factors and (e) personal factors [10]. The ICF Guide includes a new model of function and disability in humans, as shown in Figure 1 [11].

Stewart et al. stated that the ICF reflects a shift in using the term "disability" to indicate the dynamic relationship between a person and their environment. This model challenges the view that a disability is confined solely to the individual, proposing instead that disability is a social construct encompassing the relationship between the individual and the surrounding social world [12, 13]. Another significant change noted by Stewart in the ICF is the substitution of negative terms such as "impairment," "disability," and "handicap" with more positive terms like "body structures and functions," "activities," and "participation" [14, 15].

The need for functional systems to classify the severity of heterogeneous conditions, such as Cerebral Palsy (CP), was recognized in the 1990s. The most recent definition of CP acknowledges the heterogeneity of its clinical manifestations. This suggests that children with CP exhibit various clinical differences, necessitating diverse classification systems to capture this variability adequately. Each classification system used in CP has its strengths and weaknesses, but relying on a single classification does not provide a comprehensive picture of the patients. Nevertheless, a multi-axis classification has not yet been developed in CP. In this regard, any classification system must incorporate functional scales to guide treatment and rehabilitation [16].

Utilizing a classification system with proven validity presents numerous benefits. These systems improve communication between professionals and caregivers, assist in evaluating present needs, and enable parents and caregivers to predict the child's future capabilities. Functional systems, as opposed to conventional classifications, are more advantageous for educational or research purposes due to their higher levels of validity and reliability [4].

Surprisingly, evaluations of various physical abilities often rely solely on medical examinations, with functional assessments of different aspects of physical abilities, such as a child's performance in activities, being infrequent [17]. Consequently, children with CP often begin rehabilitation programs without therapists possessing specific information about their diverse functional capacities. The ICF emphasizes the importance of evaluating the functional implications of all health conditions [18]. Over the past two decades, there has been an increasing recognition of the importance of classifying

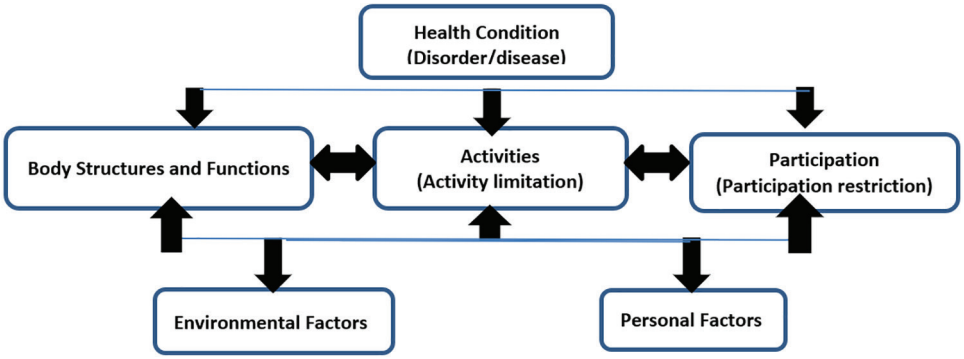

Figure 1: WHO International Classification of Function, disability and health and showing the relationship between its components

the impact of underlying CP disorders on activity and participation [11]. In response to this understanding, several classification systems have emerged. They all highlight the importance of portraying children's abilities rather than focusing exclusively on their impairments, emphasizing their behavior in real-life contexts [12].

Given the high prevalence of Cerebral Palsy (CP), the various functional disorders associated with CP, and the necessity for functional classification, this study aims to: 1. Review existing functional classification systems for children with CP based on the International Classification of Functioning, Disability, and Health (ICF). This review will identify gaps in current classification systems. 2. Examine available evidence on the relationship between these classification systems. This review will suggest future studies in classification systems for children with CP.

Materials and Methods

This study aims to review various functional classification systems based on the International Classification of Functioning, Disability, and Health (ICF) in the context of Cerebral Palsy (CP). The goal is to identify any existing gaps within these systems. The search keywords include cerebral palsy, classification system, gross motor function/ability, fine motor function/ability, arm and hand function /ability, speech and communication function/ability, eating and drinking function/ability, visual function /ability, bladder and bowel function/ability, toileting function/ability, sleeping function/ability, dressing function/ability, bathing function/ability and participation classification system.

Data for this study were gathered from various electronic databases, including Google Scholar, PubMed, ERIC, OVID, ProQuest, Scopus, Web of Knowledge, OTseeker, and Rehadat rehabilitation bases. Keywords were used in SID, Iranmedex, Noormags, Irandoc, Medlib, and Google Scholar databases until September 2022 to search for Farsi studies. The inclusion criteria were studies published in English and Farsi that included at least one classification system. Studies unrelated to International Classification of Functioning, Disability, and Health (ICF)-based classification systems and those focusing on diseases other than Cerebral Palsy (CP) were excluded. The key points of the searches are presented in a categorized manner [19]. This classification is based on the authors and the year of publication, the geographical location of the study, the study participants, the sample size, the research methodology or type of data analysis, and important results.

The Ethics Committee of the Iran University of Medical Sciences approved this study (Code: IR.IUMS.REC.1400.1111).

Results

Within the scope of this study, a total of 9,804 articles were identified from the available databases. Among these, 4,782 articles were excluded due to duplication. The title and abstract of 5,022 articles were reviewed, and 4,832 articles were discarded as they did not meet the criteria. The full text of 190 articles was studied in detail, and six ICF-based classification systems were found. Table 1 presents the results of all the articles found.

ICF-based Functional Classification Systems for children with CP

Rosenbaum et al. established the Gross Motor Function Classification System (GMFCS), a valid and reliable system. This system is based on the concepts of disability and functional limitations in the International Classification of Functioning, Disability, and Health of the World Health Organization (WHO ICF) [18]. Before the introduction of GMFCS, the limitations of gross motor function were described using terms such as "mild, moderate, and severe" without a common understanding of their meanings. The GMFCS system emphasizes spontaneous movement, particularly sitting, transferring, and moving. In defining this five-level classification system, the primary criterion was that differences between levels should be significant in everyday life. Functional limitations characterize these differences, such as the need for assistive devices (like walkers, canes, or wheelchairs) and, to a certain extent, the quality of movement. Two versions of this system for therapists and one for parents have been published [19]. Since its inception, the GMFCS has proven to be a valid and valuable tool for evaluating the daily activities and participation of individuals with Cerebral Palsy (CP), covering both children and adults. It is widely accepted among researchers and practitioners in childhood disability. Furthermore, the system has been translated into 26 languages (Table 2) [18, 20].

Table 1: The method of development and validation of functional classification systems and psychmetric properties

Year of publication	Authors	Subject of study	Population of study	Study method	Study Results
2019	Giovanni Baranello et al.	Construction and validation of a visual function classification system (VFCS)	The reliability study included 29 specialists, 39 parents and an overall sample of 160 children with CP (mean age 6 years and 6 months in the range of 1-19 years)	Includes four steps: (1) Draft five levels of literature review analysis and clinical experience (2) Validation of structures and revision of levels for conceptual significance using the nominal group process (3) Amended by the Delphi International Survey (4) Assessing the reliability between evaluators among specialists as well as caregivers, and the reliability of test-retest	The absolute agreement between the evaluators was 86%. Test-retest reliability was high. Reliability between parents and professionals in 39 average children. As a final conclusion, they stated that VFCS is properly constructed and is a reliable system for classifying the visual abilities of children with CP in the clinic and research environment.

2016	Eliasson et al.	Development of Manual ability classification for children under four years (Mini-MACS)	A sample of 61 children with CP aged 12 to 51 months was scored by a parent and two therapists for a total of 64 assessments.	Level 1: Drafting the classification system Level 2: Nominal group process Level 3: Delphi Survey Level 4: Reliability	The ICC coefficient was 0.90 between parents and therapists and 0.97 between the two therapists. Moreover, this system seems to be applicable for children with CP 1-4 years.
2014	Diane Sellers et al.	Establishing a system for classifying the eating and drinking ability (EDACS) of children with CP and evaluate its reliability	Reliability study consisting of 25 speech and language therapists and 48 parents and 129 children and people with CP (4-22 years and mean age 14 years)	Level 1: Drafting the system Level 2: Nominal group process Level 3: Delphi Survey Level 4: Reliability	Agreement and reliability between two groups of excellent therapists and between the parent group and the therapists, the agreement was moderate to substantial and the reliability was good to excellent. Finally, they concluded that the EDACS system is a valid and reliable system for classifying the ability to eat and drink in children with CP. Determining the validity and reliability of the Farsi version of the EDACS system by Riyahi et al. in 2019.
2011	Mary Cooley et al.	Establishing and validating a Communication Performance Classification System (CFCS)	Reliability between evaluators By 61 specialists and 68 parents / relatives and 69 children with CP 2 to 18 years	An 11-member development team developed comprehensive descriptions of CFCS levels and reviewed four nominal groups of 27 participants. In a Delphi survey, 112 respondents commented on the clarity and usefulness of CFCS. Reliability between evaluators was completed by 61 specialists and 68 parents / relatives who classified 69 children with CP. Test-retest reliability was completed by 48 specialists with a minimum interval of 2 weeks between classifications.	Reliability between the two specialists was 0.66 and between the parent and the specialist was 0.49. Reliability among evaluators among specialists for classifying children over 4 years of age had reached 0.77. The reliability of the test-retest was 0.82. CFCS interpretation showed content validity and test-retest reliability very good. Reliability between good evaluators among experts and reliablity between average evaluators among parents/experts. Determining the validity and reliabilty of the Farsi version of CFCS system by Soleimani et al. in 2015.
2008	Rosenbaum et al.	Construction, validity and reliability of a large motor function classification system in children with CP	110 children with CP 2-18 years	Level 1: Drafting the system Level 2: Nominal group process Level 3: Delphi Survey Level 4: Reliability	In this study, the reliability between the evaluators as well as the reliability of the test repetition was high. The positive predictive validity of GMFCS for predicting gait from 1 to 2 years of age up to 12 years of age was 0.74. Determining the validity and reliability of the Farsi version of the GMFCS system by Dehghan et al. in 2010 Evaluation of validity and reliability of the test - Parental version retest and reliability between therapists' prescription and GMFCS parental prescription by Riahi et al. in 2012
2006	Eliasson et al.	Manual Ability Classification System (MACS) for children with CP, how valid and reliable	Reliability between therapists for 168 children aged 4-18 years and 25 parents and pediatricians	Its validity was based on the experience of a skilled group, a review of articles, and a comprehensive analysis of children in a range of practices, resulting in a consensus on structures as well as on the content of the five levels. Then parents and therapists were interviewed about the content, simplicity and ease, explanation and preference of each level. Reliability was also assessed between therapists for 168 children aged 4-18 years and 25 parents and pediatric therapists.	The results showed that MACS has good validity and reliability. The internal correlation coefficient between therapists was 0.97 and between parents and therapists was 0.96, which is a sign of excellent agreement. Determining the validity and reliability of the Farsi version of the MACS system by Riahi et al. in 2013

Table 2: Reliability of the Gross Motor Function Classification System

Source	Type of Reliability	Subject Age Range, y	Reliability Statistics
Palisano et al [34]	Inter-rater reliability		ICC=0.96
	Inter-rater reliability	Older than 2 years of age	K=0.75
	Inter-rater reliability	Under 2 years of age	K=0.55
Randall et al [35]	Inter-rater reliability	4-11	0.98
Wood et al [36]	Inter-rater reliability	2-12	G=0.93
	Test–retest reliability	G=0.79	
Palisano et al [37]	Inter-rater reliability	Under 2 years of age	K=0.55
	Inter-rater reliability	2-12	K=0.75
Russell et al [38]	Test-retest reliability	Over 12 months	ICC=0.99
Bodkin et al [39]	Interrater reliability	Younger than two years old	K=0.55
	Interrater reliability	Two to 12 years old	K=0.75
El et al [40]	Test-retest reliability	12-18	ICC=0.97
		ICC=0.94	
Papavasiliou et al [41]		Mean age 5.4 years	K=0.80
Piscitelli et al [42]	Inter- reliability		K=0.97
	Intra-rater reliability		K=0.98
	GMFCS by parents		
Riyahi et al [43]		2-12	ICC=0.92
			K=0.61
	GMFCS by therapists And parents		
		2-12	ICC=0.88
			K=0.68
Dehghan et al [44]	Interrater reliability (IRR)		P<0.05

ICC: Intraclass correlation coefficient; K: kappa coefficient; GMFCS: Gross Motor Function Classification System; IRR: Inter-rater reliability

Table 3: Reliability of the Manual Ability Classification System

Source	Type of Reliability	MACS Version	Subject Age Range, y	Reliability Statistics
Eliasson et al [21]	Interrater reliability	Original version	4-18	ICC=0.97
Van Meeteren et al [45]	Interrater reliability	Original version	18-24	ICC=0.83
Plasschaert et al [46]	Interrater reliability	Original version	1-5	K=0.55 (younger than 2 y)
				κ=0.67 (2-5 y of age)
Jang et al [47]	Interrater reliability	Korean version	4-14	ICC=0.92-0.96
	Interrater reliability	Korean version	4-14	ICC=0.96-0.98
Akpinar et al	Interrater reliability	Turkish version	4-18	ICC=0.89-0.98
	Test retest reliability	Turkish version	4-18	ICC=0.91-0.98
Riyahi et al [19]	Interrater reliability	Farsi version	4-18	ICC=0.96
	Test retest reliability	Farsi version	4-18	ICC=0.97
Morris et al [48]	Interrater reliability	Original version	6-12	ICC=0.7-0.9
Mutlu et al [49]	Interrater reliability	Turkish version	4-18	ICC=0.96
Randall et al [35]	Interrater reliability	Original version	4-11	κ=1

ICC: Intraclass correlation coefficient; K: kappa coefficient; MACS: Manual Ability Classification System

Another scale that complements the GMFCS is the Bimanual Fine Motor Function Scale (BFMF), designed to assess upper limb function in Cerebral Palsy (CP). However, it has received less attention than the GMFCS. A more recent classification system for evaluating arm and hand function is the Manual Ability Classification System (MACS), introduced by Eliasson et al. This system has shown reliability among both parents and professionals. The MACS outlines limitations in manual ability for children aged 4-18 years with CP. Before the development of MACS, existing classification systems for manual functions did not adequately represent everyday functioning, such as a child's activities in daily life. These systems either focus solely on manual function, like the House classification, modified House classification, and Zancolli classification, or on manual functional capacity, such as bimanual fine motor function.

Therefore, there is a need for a straightforward and reliable tool that specifically evaluates performance in daily activities, providing deeper insights into a child's everyday functioning [20]. The five-level Manual Ability Classification System (MACS) accurately depicts how children with CP use their hands to manipulate objects in their daily lives [19, 21]. The MACS has demonstrated strong validity and reliability and has gained international recognition, being translated into 27 languages [19]. Riyahi et al. translated this tool into Persian in 2012 (Table 3) [19].

In 2013, Eliasson and his team introduced another version of the MACS system for children aged 1-4 years, known as Mini-MACS. This version has been translated into 14 languages. In 2017, Riyahi et al. translated this new version into Farsi. The validity and reliability of the Farsi version were subsequently investigated [22, 23].

The Communication Function Classification System (CFCS) provides an alternative approach by categorizing the daily communication function of individuals with Cerebral Palsy (CP) into five levels. These levels are based on descriptions of activity and participation.

Table 4: Reliability of the Communication Function Classification System

Source	Type of Reliability	Subject Age Range, y	Reliability Statistics
Hidecker et al [50]	Inter-rater reliability	2-18	K=0.82
Randall et al [35]	Inter-rater reliability	4-11	0.98
Soleymani et al [51]	Between speech and language pathologists and occupational therapists		
	Inter-rater reliability	2-18	0.81
	Between parents and occupational therapists		
	Inter-rater reliability	2-18	0.74
	Between parents and speech and language pathologists		
	Inter-rater reliability	2-18	0.88
	For occupational therapists		
	Test-retest reliability	2-18	0.96
	For speech and language pathologists		
	Test-retest reliability	2-18	0.98
	For parents		
	Test-retest reliability	2-18	0.94
Vander Zwart et al [52]	Between parents and SLTs		
	Interrater reliability	Range 2y 9mo–12y 10mo	*r*=0.54
	Between SLTs		
	Interrater reliability	Range 2y 9mo–12y 10mo	*r*=0.78
	SLT		
	intrarater reliability	Range 2y 9mo–12y 10mo	*r*=0.85

Table 5: Reliability measures associated with use of Eating and Drinking Ability Classification System (EDACS) by speech and language therapists (SaLTs)

Source	Reliability of EDACS levels	Subject Age Range, y	Reliability Statistics
Sellers et al [53]	Reliability of EDACS levels I to V	4-22	K=0.72
			ICC=0.93
	Reliability of EDACS levels of assistance		k=0.80
			ICC=0.92
Tschirren et al [54]	Interrater reliability of EDACS	Mean age 9y 7mo	κ=0.94
	Interrater Reliability of EDACS level of assistance		κ=0.89
Reliability measures associated with use of EDACS by speech and language therapists and parents			
Sellers et al [53]	Reliability of EDACS levels I to V	4-22	k=0.45
			ICC=0.86
	Reliability of EDACS levels of assistance		k=0.64
			ICC=0.77
Tschirren et al [54]	Interrater reliability of EDACS	Mean age 9y 7mo	κ=0.82
	Interrater Reliability of EDACS level of assistance		κ=0.89

EDACS: Eating and Drinking Ability Classification System; SaLTs: Speech and language therapists; K: Kappa coefficient; ICC: Intraclass correlation coefficient

The CFCS system emphasizes the importance of both understanding and expressing messages. Classification within the CFCS system is determined by the individual's reliance on alternative communication methods, such as signs and symbols or audio communication aids [24]. The CFCS has been translated into 26 languages, and in 2015, Soleimani et al. translated it into Persian (Table 4) [25].

Despite several classification systems, a specific classification system emerged to address eating and drinking ability, known as EDACS. This system characterizes the functional capacity of individuals with CP to consume food and beverages, applicable from the age of 3 and onward. The key components of the EDACS system include safety considerations regarding the risk of choking or aspiration, as well as efficiency metrics related to time spent and food/fluid loss. These metrics underscore limitations in oral skills required for biting, chewing, and swallowing [24]. The assistance required during meals is detailed on a separate scale. The EDACS system complements existing systems like GMFCS, MACS, and CFCS, thereby adding a new dimension to the array of classification systems to describe functional performance in the daily lives of those with CP (Table 5) [24, 25].

The most recent classification system is the Visual Function Classification System (VFCS), developed and validated by Giovanni Baranello et al. in 2019. This reliable five-level classification system uses visual abilities to describe toddlers and adolescents with CP daily. The VFCS validation is performed for children from 1 to 19 years old. Following all CP classifications, this system should not be used as an assessment tool; it does not explain the fundamental reasons for visual function abilities and highlights functional abilities rather than limitations. It describes the normal daily functioning of an affected child instead of their best capacity, and the lowest level is related to better performance. This is why it is important to consider daily situations in a typical environment when classifying the level of visual function of a child with CP. This classification can be performed by anyone familiar with a person's visual functioning abilities, including parents, carers, therapists, physicians, and the individuals themselves (Table 6) [24].

Table 6: General summary headings for the GMFCS, MACS, Mini-MACS, CFCS, EDACS and VFCS

Scale	Level 1	Level 2	Level 3	Level 4	Level 5
GMFCS (aged 0–18)	Walks without Limitations	Walks with Limitations	Walks Using a Hand-Held Mobility Device	Self-Mobility with Limitations; May Use Powered Mobility	Transported in a Manual Wheelchair
MACS (aged 4–18)	Handles objects easily and successfully.	Handles most objects but with somewhat reduced quality and/or speed of achievement.	Handles objects with difficulty; needs help to prepare and/or modify activities.	Handles a limited selection of easily managed objects in adapted situations	Does not handle objects and has severely limited ability to perform even simple actions.
Mini-MACS (aged 1–4)	Handles objects easily and successfully	Handles most objects, but with somewhat reduced quality and/or speed of achievement.	Handles objects with difficulty.	Handles a limited selection of easily managed objects in simple actions.	Does not handle objects and has severely limited ability to perform even simple actions.
CFCS (aged 2–18)	Sends and receives with familiar and unfamiliar partners effectively and efficiency	Sends and receives with familiar and unfamiliar partners but may need extra time	Sends and receives with familiar partners effectively, but not with unfamiliar partners	Inconsistently sends and/or receives even with familiar partners	Seldom effectively sends and receives, even with familiar partners
EDACS (aged 3–18)	Eats and drinks safely and efficiently	Eats and drinks safely but with some limitations to efficiency	Eats and drinks with some limitations to safety; there may be limitations to efficiency	Eats and drinks with significant limitations to safety	Unable to eat and drink safely – tube feeding may be considered to provide nutrition
VFCS (aged 1–19)	Uses visual function easily and successfully in vision- related activities	Uses visual function successfully but needs self- initiated compensatory strategies	Uses visual function but needs some adaptations	Uses visual function in very adapted environments but performs just part of vision- related activities	Does not use visual function even in very adapted environments

GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; Mini-MACS: Mini Manual Ability Classification System; CFCS: Communication Function Classification System; EDACS: Eating and Drinking Ability Classification System; VFCS: Visual Function Classification System

Table 7: Relationship between Functional Classification Systems in Cerebral Palsy

Riyahi et al. in 2022 [29]	MACS- GMFCS-CFCS-EDACS	There is a moderate and significant relationship between the MACS and the EDACS, the MACS and the CFCS, and the CFCS and the EDACS in children with CP.
Mutlu A et al. in 2018 [55]	GMFCS-MACS-CFCS	GMFCS levels showed a strong correlation with MACS levels (rs=0.78). MACS level was strongly correlated with CFCS levels (rs=0.73), particularly in quadriplegic children (rs=0.78). GMFCS levels were moderately correlated with CFCS levels (rs=0.71).
Margarta et al. in 2017 [27]	GMFCS-MACS-CFCS-EDACS	A high correlation between the four classifications was found ($r > 0.70$, $p < 0.01$).
Killian et al. in 2014 [26]	GMFCS-MACS-CFCS	There were moderate positive correlations between three FCS: GMFCS and MACS (T were no significant correlations between CFCS and the other FCS).
Compagnone E et al. in 2014 [56]	GMFCS-MACS-CFCS	A strong correlation was found between the three classifications: Level V of the GMFCS-E&R corresponds to Level V of the MACS (rs=0.67, p=0.001); the same relationship was found for the CFCS and the MACS (rs=0.73, p<0.001) and for the GMFCS-E&R and the CFCS (rs=0.61, p=0.001).
Oskoui et al. in 2013 [57]	GMFCS–MACS	The overall agreement between GMFCS and MACS Levels was moderate (kappa 0.457, standard error 0.034) with a strong positive correlation (Spearman rho of 0.820, standard error 0.023).
Himmelman et al. in 2013 [58]	CFCS-GMFCS-MACS	CFCS correlated with the GMFCS, MACS and cognitive function ($p < 0.01$).
Riyahi et al. in 2013 [19]	GMFCS-MACS	Correlation between GMFCS and MACS was also calculated, this demonstrated a moderate relationship (P=0.727).
Heidecker et al. in 2012 [50]	GMFCS–MACS	GMFCS levels were strongly correlated with MACS levels (rs=0.69, p<0.001).
Heidecker et al. in 2012 [50]	MACS–CFCS	MACS levels were moderately correlated with CFCS levels (rs=0.54, p<0.001).
Heidecker et al. in 2012 [50]	GMFCS–CFCS	GMFCS levels were moderately correlated with CFCS levels (rs=0.47, p<0.001),
Akpinar P. et al. in 2010 [30]	GMFCS–MACS	Total agreement between the GMFCS and the MACS occurred in only 45% of the children.
Gunel MK et al. in 2009 [59]	GMFCS–MACS-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.
Carnahan KD et al. in 2007 [60]	GMFCS–MACS	The overall agreement between GMFCS and MACS was poor (kappa value 0.35, 95% confidence interval 0.27–0.41).
Eliasson AC et al. in 2006 [21]	GMFCS–MACS	Correlation between GMFCS and MACS was also calculated, this demonstrated a moderate relationship.

MACS: Manual Ability Classification System; GMFCS: Gross Motor Function Classification System; CFCS: Communication Function Classification System; EDACS: Eating and Drinking Ability Classification System; WeeFIM: Functional Independence Measure

Relationship between Functional Classification Systems in Cerebral Palsy

In a study conducted by Calis et al., 166 children diagnosed with CP and classified as GMFCS levels IV and V were examined. The research findings indicated that individuals at GMFCS level V exhibited more severe swallowing issues. This resulted in the need for dietary restrictions, the utilization of swallowing strategies, and reliance on others for feeding [25]. Similarly, a study by Heidecker explored the correlation between GMFCS, MACS, and CFCS, revealing a moderate to strong relationship [26].

In the study conducted by Oskoui et al., a correlation was identified between gross motor function and manual ability in children with cerebral palsy [25]. Weir et al. discovered that self-reported eating ability in young children with CP, aged between 1 and 3 years, was significantly correlated with their gross motor function abilities [26]. Coleman et al. examined the relationship between communication skills and gross motor performance in preschool children with CP. Their findings suggested that a decrease in gross motor skills reduced communication ability [27]. Similarly, Himmelman et al. investigated the ability to communicate in individuals with CP and concluded that the CFCS is correlated with GMFCS, MACS, and cognitive function [28].

Akmer et al. conducted a study exploring the distribution and correlation between GMFCS, MACS, and CFCS in children with spastic CP. They found a strong correlation between gross motor function levels and manual ability levels, particularly in children with quadriplegia. Additionally, manual ability levels exhibited significant correlations with communication function levels. Interestingly, GMFCS and CFCS levels displayed a moderate correlation [25]. In contrast, Killian et al. found no substantial correlation between GMFCS and CFCS [26]. Margarta et al., also in 2017, delved into the correlation between GMFCS and CFCS levels in CP-afflicted children, identifying a moderate correlation across all studied samples [27]. Moving forward to 2019, Montero-Mendoza and Calvo-Muñoz reported a strong correlation among GMFCS, MACS, CFCS, and EDACS in a cohort of 52 CP-diagnosed children aged 3 to 18 years in Spain [28]. In a more recent study conducted in 2022, Riyahi et al. discovered a significant and moderate relationship between MACS and EDACS, MACS, and CFCS, and CFCS and EDACS in children with CP. They also observed that children with more pronounced motor function limitations tended to exhibit greater limitations in other functional classification systems. However, they underscored the need for further research due to the limited number of studies in this domain [29] (Table 7).

Discussion

Cerebral Palsy (CP), being one of the most prevalent neurological disorders in children, is often compounded by comorbidities, complicating treatment approaches [30]. These impairments include intellectual disability, seizures, hearing, vision, speech, and nutritional impairment [31]. In heterogeneous conditions such as CP, mere definitions like ‘mild’, ‘moderate’, and ‘severe’ about functional limitations caused by the disease are not sufficient. A focus on the level of body structures and functions, activity, or participation is essential [32]. Therefore, the validation of scales to accurately evaluate and adjust an effective treatment plan for people with CP is necessary. Diagnostic tools and evaluations in conjunction with these scales will provide a comprehensive picture of abilities and disabilities in various body functions. Subsequently, we can adopt effective therapeutic interventions, improving the attitude and knowledge among families and therapists, allocating resources, and facilitating studies on the causes, prevention, or prognosis.

According to the findings of this study, several classification systems, such as GMFCS, MACS, and its smaller version, Mini-MACS, CFCS, EDACS, and VFCS, have been developed to date. These systems improve and simplify the description of children with CP and operate robustly and effectively. Over time, these classifications have proven to be valid and reliable. Professionals and family members can evaluate these scales quickly and accurately with proper training. The simplicity and comprehensiveness of these classification systems have reshaped our understanding of children with CP and enhanced the quality of their care [10]. It should be noted that these systems are used solely to classify the different functional abilities of people with CP and cannot be used as an outcome measure.

Numerous studies have explored the interplay among these classification systems, revealing conflicts and inconsistencies in their findings, likely stemming from variations in study conditions. However, the overall results favor a roughly moderate association among these classification systems [33]. To gain a better understanding of the relationship among the classification systems, further studies are required. In addition, the relationship among the classifications has been moderate on average, indicating that one or more classifications alone cannot provide a complete picture of the clients. In other words, classifications for other functional aspects, such as toileting and dressing, are needed.

Cerebral Palsy (CP) and its associated impairments impact many aspects of an individual’s body structures and functions. However, this review revealed that a functional classification system has not yet been designed for some aspects.

CP severely affects the ability to control urination and defecation and, in general, toileting, dressing, bathing, and other self-care activities. The disturbances in perception, cognition, sensation, and movement resulting from the disease challenge these abilities. No clear and practical classifications have yet been developed for these significant functional aspects.

Sleep function is also among the aspects that might affect children with CP. This can negatively impact the execution of daily activities and limit the extent of these individuals’ participation and independence. No system has been developed to classify this dimension of functional restrictions.

While activity limitations are crucial, it’s equally

important to consider how movement disorders impact the ability to engage in preferred social roles. Although the assessment of participation limitations in CP is still under development, the accurate classification of children based on this aspect of daily life remains an unresolved issue. Among the limitations of this study are the limited access to databases for article searches and the unavailability of the full text of some articles.

Conclusion

Based on the findings of this review, there is a significant gap in the systems used to classify various functions. This gap is crucial for evaluating rehabilitation outcomes, setting appropriate goals, formulating effective treatment plans to reintegrate patients into their homes and communities, and providing timely and suitable services to ensure their independence in daily life activities. Integrating these complementary systems with the existing six classification systems can enhance our understanding of the critical functional abilities of individuals with Cerebral Palsy (CP) and provide a comprehensive view of their overall functioning.

Despite the importance of using these systems in managing cerebral palsy, some newer classification systems are not as widely used in practice as previous classifications. This could be due to reasons such as the lack of translation of the original version, lack of validity and reliability in the culture, unfamiliarity with the classification system and how to score it, lack of knowledge of their importance, application, and benefits of these systems in assessing and treating people with CP, or problems in the integration of these classification systems into the clinical environment.

Moreover, the following suggestions can help improve the classifications and their use in various settings: 1. Translating these classification systems into different languages, including Farsi; 2. Training on how to use these systems in the form of workshops; 3. Using these classification systems in the clinical setting (to be part of clinical evaluation forms); 4. Using these classification systems in research; and 5. Designing and constructing other classification systems for functions such as toileting, bathing, dressing, and sleeping.

Acknowledgment

The authors are grateful to all who contributed to this study.

Conflict of Interest: None declared.

References

1. Odding E, Roebroeck ME, Stam HJ. The epidemiology of cerebral palsy: incidence, impairments and risk factors. Disability and rehabilitation. 2006;28(4):183-91.
2. Sankar C, Mundkur N. Cerebral palsy-definition, classification, etiology and early diagnosis. The Indian Journal of Pediatrics. 2005;72(10):865-8.
3. Rogers B. Feeding method and health outcomes of children with cerebral palsy. The Journal of pediatrics. 2004;145(2):S28-S32.
4. Rosenbaum P. The definition and classification of cerebral palsy: are we any further ahead in 2006? NeoReviews. 2006;7(11):e569-e74.
5. Stanley FJ, Blair E, Alberman E. Cerebral palsies: epidemiology and causal pathways: Cambridge University Press; 2000.
6. Rassafiani M, Kahjoogh MA, Hosseini A, Sahaf R. Time use in mothers of children with cerebral palsy: A comparison study. Hong Kong Journal of Occupational Therapy. 2012;22(2):70-4.
7. Rosenbaum P, Eliasson A-C, Hidecker MJC, Palisano RJ. Classification in childhood disability: focusing on function in the 21st century. Journal of child neurology. 2014;29(8):1036-45.
8. Paulson A, Vargus-Adams J. Overview of four functional classification systems commonly used in cerebral palsy. Children. 2017;4(4):30.
9. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, et al. Proposed definition and classification of cerebral palsy, April 2005. Developmental medicine and child neurology. 2005;47(8):571-6.
10. Schiariti V, Mâsse LC. Relevant areas of functioning in children with cerebral palsy based on the international classification of functioning, disability and health coding system: a clinical perspective. Journal of child neurology. 2015;30(2):216-22.
11. Organization WH. International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY: World Health Organization; 2007.
12. Rosenbaum P, Stewart D, editors. The World Health Organization International Classification of Functioning, Disability, and Health: a model to guide clinical thinking, practice and research in the field of cerebral palsy. Seminars in pediatric neurology; 2004: Elsevier.
13. Steiner WA, Ryser L, Huber E, Uebelhart D, Aeschlimann A, Stucki G. Use of the ICF model as a clinical problem-solving tool in physical therapy and rehabilitation medicine. Physical therapy. 2002;82(11):1098-107.
14. Bruyère SM, Van Looy SA, Peterson DB. The international classification of functioning, disability and health: Contemporary literature overview. Rehabilitation Psychology. 2005;50(2):113.
15. Cramm H, Aiken AB, Stewart D. Perspectives on the International Classification of Functioning, Disability, and Health: Child and Youth version (ICF-CY) and occupational therapy practice. Physical & Occupational Therapy in Pediatrics. 2012;32(4):388-403.
16. Ogoke CC. Clinical Classification of Cerebral Palsy. Cerebral Palsy-Clinical and Therapeutic Aspects: IntechOpen; 2018.
17. Dutton GN, Calvert J, Cockburn D, Ibrahim H, Macintyre-Beon C. Visual disorders in children with cerebral palsy: the implications for rehabilitation programs and school work. Eastern Journal of Medicine. 2012;17(4):178-87.
18. Dehghan L, Abdolvahab M, Bagheri H, Dalvand H, FAGHIH ZS. Inter rater reliability of Persian version of Gross Motor Function Classification System Expanded and Revised in patients with cerebral palsy. 2011.
19. Riyahi A, Rassafiani M, AkbarFahimi N, Sahaf R, Yazdani F. Cross-cultural validation of the Persian version of the Manual Ability Classification System for children with cerebral palsy. International Journal of Therapy and Rehabilitation. 2013;20(1):19-24.
20. Riahi A, Rassafiani M, Binesh M. The cross-cultural validation and test-retest and inter-rater reliability of the Persian translation of parent version of the Gross Motor Function Classification System for children with Cerebral Palsy. Archives of Rehabilitation. 2013;13:25-30.
21. Eliasson A-C, Krumlinde-Sundholm L, Rösblad B, Beckung E, Arner M, Öhrvall A-M, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Developmental medicine and child neurology. 2006;48(7):549-54.
22. Eliasson AC, Ullenhag A, Wahlström U, Krumlinde-Sundholm L. Mini-MACS: development of the Manual Ability Classification System for children younger than 4 years of age with signs of cerebral palsy. Developmental Medicine & Child Neurology. 2017;59(1):72-8.
23. Riyahi A, Akbarfahimi N, Sarlak N, Abdolrazaghi H, Nobakht Z. Validating the reliability and validity of the Persian Version of the mini-manual ability classification system. Journal of Rehabilitation Sciences & Research. 2023;10(4):203-8.
24. Baranello G, Signorini S, Tinelli F, Guzzetta A, Pagliano E, Rossi A, et al. Visual Function Classification System for children with cerebral palsy: development and validation. Developmental Medicine & Child Neurology. 2020;62(1):104-10.
25. Mutlu A, Pistav-Akmese P, Yardımcı BN, Ogretmen T. What do the relationships between functional classification systems of children with cerebral palsy tell us? Journal of Physical Therapy Science. 2017;28(12):3493-8.

26. Killian L, Bryant E, Sellers D, editors. The clinical use of functional classification systems for children and young people with cerebral palsy. Abstracts of the European Academy of Childhood Disability 26th Annual Meeting; 2014.
27. Margaretha V, Prananta MS, Alam A. Correlation between gross motor function classification system and communication function classification system in children with cerebral palsy. Althea Medical Journal. 2017;4(2):221-7.
28. Montero-Mendoza S, Calvo-Muñoz I. Analysis of relationship among the functional classification systems in cerebral palsy and the different types according to the Surveillance of Cerebral Palsy in Europe.
29. Riyahi A, Nobakht Z, Soleimani F, Rahmani N, Sajedi F. Relationship Between Functional Classification Systems in Children With Cerebral Palsy. Archives of Rehabilitation. 2022;23(4):502-17.
30. Akpinar P, Tezel CG, Eliasson A-C, Icagasioglu A. Reliability and cross-cultural validation of the Turkish version of Manual Ability Classification System (MACS) for children with cerebral palsy. Disability and rehabilitation. 2010;32(23):1910-6.
31. Rassafiani M, Ziviani J, Rodger S, Dalgleish L. Managing upper limb hypertonicity: Factors influencing therapists' decisions. British Journal of Occupational Therapy. 2006;69(8):373-8.
32. Sellers D, Pennington L, Mandy A, Morris C. A systematic review of ordinal scales used to classify the eating and drinking abilities of individuals with cerebral palsy. Developmental Medicine & Child Neurology. 2014;56(4):313-22.
33. Goh Y-r, Choi JY, Kim SA, Park J, Park ES. Comparisons of severity classification systems for oropharyngeal dysfunction in children with cerebral palsy: Relations with other functional profiles. Research in developmental disabilities. 2018;72:248-56.
34. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. Developmental Medicine & Child Neurology. 2008;50(10):744-50.
35. Randall M, Harvey A, Imms C, Reid S, Lee KJ, Reddihough D. Reliable classification of functional profiles and movement disorders of children with cerebral palsy. Physical & occupational therapy in pediatrics. 2013;33(3):342-52.
36. Wood E, Rosenbaum P. The gross motor function classification system for cerebral palsy: a study of reliability and stability over time. Developmental medicine and child neurology. 2000;42(5):292-6.
37. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Developmental Medicine & Child Neurology. 1997;39(4):214-23.
38. Russell DJ, Avery LM, Rosenbaum PL, Raina PS, Walter SD, Palisano RJ. Improved scaling of the gross motor function measure for children with cerebral palsy: evidence of reliability and validity. Physical therapy. 2000;80(9):873-85.
39. Bodkin AW, Robinson C, Perales FP. Reliability and validity of the gross motor function classification system for cerebral palsy. Pediatric Physical Therapy. 2003;15(4):247-52.
40. El Ö, Baydar M, Berk H, Peker Ö, Koşay C, Demiral Y. Interobserver reliability of the Turkish version of the expanded and revised gross motor function classification system. Disability and rehabilitation. 2012;34(12):1030-3.
41. Papavasiliou A, Rapidi C, Rizou C, Petropoulou K, Tzavara C. Reliability of Greek version gross motor function classification system. Brain and Development. 2007;29(2):79-82.
42. Piscitelli D, Vercelli S, Meroni R, Zagnoni G, Pellicciari L. Reliability of the gross motor function classification system and the manual ability classification system in children with cerebral palsy in Tanzania. Developmental neurorehabilitation. 2017:1-7.
43. Riahi A, Rassafiani M, Binesh M. The cross-cultural validation and test-retest and inter-rater reliability of the Persian translation of parent version of the Gross Motor Function Classification System for children with Cerebral Palsy. Journal of Rehabilitation. 2013;13(5):25-30.
44. Dehghan L, Abdolvahab M, Bagheri H, Dalvand H. Inter rater reliability of Persian version of Gross Motor Function Classification System Expanded and Revised in patients with cerebral palsy. Daneshvar. 2011;18(91):37-44.
45. van Meeteren J, Nieuwenhuijsen C, de Grund A, Stam HJ, Roebroeck ME. Using the manual ability classification system in young adults with cerebral palsy and normal intelligence. Disability and rehabilitation. 2010;32(23):1885-93.
46. Plasschaert V, Ketelaar M, Nijnuis M, Enkelaar L, Gorter J. Classification of manual abilities in children with cerebral palsy under 5 years of age: how reliable is the Manual Ability Classification System? Clinical rehabilitation. 2009;23(2):164-70.
47. Jang DH, Sung I, Kang J, Lee S, Park J, Yuk J, et al. Reliability and validity of the Korean version of the manual ability classification system for children with cerebral palsy. Child: care, health and development. 2013;39(1):90-3.
48. Morris C, Kurinczuk JJ, Fitzpatrick R, Rosenbaum PL. Reliability of the manual ability classification system for children with cerebral palsy. Developmental medicine and child neurology. 2006;48(12):950-3.
49. Mutlu A, Kara OK, Gunel MK, Karahan S, Livanelioglu A. Agreement between parents and clinicians for the motor functional classification systems of children with cerebral palsy. Disability and rehabilitation. 2011;33(11):927-32.
50. Hidecker MJC, Paneth N, Rosenbaum PL, Kent RD, Lillie J, Eulenberg JB, et al. Developing and validating the Communication Function Classification System for individuals with cerebral palsy. Developmental Medicine & Child Neurology. 2011;53(8):704-10.
51. Soleymani Z, Joveini G, Baghestani AR. The Communication Function Classification System: Cultural Adaptation, Validity, and Reliability of the Farsi Version for Patients With Cerebral Palsy. Pediatric neurology. 2015;52(3):333-7.
52. Vander Zwart KE, Geytenbeek JJ, De Kleijn M, Oostrom KJ, Gorter JW, Hidecker MJC, et al. Reliability of the Dutch-language version of the Communication Function Classification System and its association with language comprehension and method of communication. Developmental Medicine & Child Neurology. 2016;58(2):180-8.
53. Sellers D, Mandy A, Pennington L, Hankins M, Morris C. Development and reliability of a system to classify the eating and drinking ability of people with cerebral palsy. Developmental Medicine & Child Neurology. 2014;56(3):245-51.
54. Tschirren L, Bauer S, Hanser C, Marsico P, Sellers D, van Hedel HJ. The Eating and Drinking Ability Classification System: concurrent validity and reliability in children with cerebral palsy. Developmental Medicine & Child Neurology. 2018;60(6):611-7.
55. Mutlu A, Kara ÖK, Livanelioğlu A, Karahan S, Alkan H, Yardımcı BN, et al. Agreement between parents and clinicians on the communication function levels and relationship of classification systems of children with cerebral palsy. Disability and health journal. 2018;11(2):281-6.
56. Compagnone E, Maniglio J, Camposeo S, Vespino T, Losito L, De Rinaldis M, et al. Functional classifications for cerebral palsy: correlations between the gross motor function classification system (GMFCS), the manual ability classification system (MACS) and the communication function classification system (CFCS). Research in developmental disabilities. 2014;35(11):2651-7.
57. Oskoui M, Majnemer A, Dagenais L, Shevell MI. The relationship between gross motor function and manual ability in cerebral palsy. Journal of Child Neurology. 2013;28(12):1646-52.
58. Himmelmann K, Lindh K, Hidecker MJC. Communication ability in cerebral palsy: a study from the CP register of western Sweden. European Journal of Paediatric Neurology. 2013;17(6):568-74.
59. 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. European journal of pediatrics. 2009;168(4):477-85.
60. Carnahan KD, Arner M, Hägglund G. Association between gross motor function (GMFCS) and manual ability (MACS) in children with cerebral palsy. A population-based study of 359 children. BMC Musculoskeletal Disorders. 2007;8(1):1-7.