



Original Article

Associations between impairments and activity limitations components of the international classification of functioning and the gross motor function and subtypes of children with cerebral palsy

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Abstract. [Purpose] Cerebral palsy (CP) encompasses a group of disorders of movement and posture with wide ranges of impairments, activity limitations and participation restrictions. Guiding management of children with CP by the ICF model is important to deliver quality services. This study aimed to explore relationship between CP subtypes and the Gross Motor Function Classification System-Expanded and Revised (GMFCS-E&R) and to examine differences in distribution of impairments and activity limitations across CP subtypes and GMFCS-E&R levels. [Participants and Methods] 70 children with CP (mean age: 6.5 ± 2.9 years) were classified using CP subtypes and GMFCS-E&R. Research assistants examined impairments including: scoliosis, scissoring, and inability to bear weight. Parents described their children's transfers and functional mobility. [Results] CP subtypes and GMFCS-E&R levels were significantly associated. Scissoring and scoliosis were predominant in children in levels IV and V of the GMFCS-E&R. Only scoliosis was predominant in children with quadriplegia. Transfer activities and functional mobility were more limited in children with quadriplegia and in level V of the GMFCS-E&R. [Conclusion] Impairments and activity limitations components of the ICF can be differentiated by CP subtypes and GMFCS-E&R. Clinicians can use the two classification in providing comprehensive and individualized services for children with CP and their families.

Key words: Cerebral palsy, ICF, GMFCS-E&R

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INTRODUCTION

Cerebral Palsy (CP) is a life-long disorder of movement and posture causing a heterogeneous and wide spectrum of impairments, functional limitations and challenges in participating in everyday activities^{1, 2)}. The heterogeneity of CP leads to variations in children's needs, and consequently, required medical and rehabilitation services. Therefore, children with CP are usually classified into subgroups based on distribution of motor impairments or gross motor functional abilities. Classification based on distribution of motor impairments categorizes children based on topographical pattern and quality of motor impairment into spastic hemiplegia, spastic diplegia, spastic quadriplegia, dyskinesia, and ataxia^{1, 3, 4)}. This classifica-

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tion is widely used by clinicians and researchers; however, its reliability is questionable due to lack of unified operational definitions^{5, 6}. In addition, it cannot be used to identify functional limitations, or evaluate changes in child's function over time^{1, 7}. The gross motor functional classification on the other hand, focuses on gross motor abilities of the child with CP^{6, 8}. The Gross Motor Function Classification System (GMFCS-E&R)⁹ classifies children with CP based on gross motor function into five functional levels; Level I indicates minimal limitations while Level V indicates maximal limitations⁹.

The aforementioned classifications provide different, yet complementary information about children with CP¹⁰⁻¹². Previous research showed that children with spastic hemiplegia subtype were mostly classified in levels I and II of the GMFCS; while children with diplegia and quadriplegic subtypes were mostly classified in levels IV&V of the GMFCS. Understanding the relationship between CP subtypes and gross motor function and exploring the distribution of children with CP across CP subtypes and GMFCS levels can guide service providers in implementing plans of care based on functional status and specific needs of children in each category.

The International Classification of Functioning, Disability and Health (ICF) is a valuable framework that guides comprehensive evaluation and treatment of children with CP taking into consideration the wide spectrum of health related problems they face. The ICF includes four interrelated components: body functions and structures, activities and participation, personal, and environmental factors¹³. Understanding associations among different components of the ICF model is important to establish realistic treatment goals and interventions that improve activities and participation of children with CP^{6, 12}. Therefore, it is important to examine associations and describe differences in distribution of impairments and activity limitations across CP subtypes and GMFCS-E&R levels. This knowledge is expected to guide planning of services that target specific impairments and activity limitations of each group of children. In addition, resources available for children with CP and their families can be allocated to respond to specific needs.

In Jordan, most of service providers do not use CP classifications to guide their plans of care, in addition, they provide services that are focused on impairments rather than on activities and participation¹⁴. Therefore, the findings of this study are expected to improve our knowledge about distribution of impairments and activity limitations across CP categories. This knowledge is important in guiding service providers to establish plans of care that are responsive to the variety (by using classifications) and heterogeneity (by addressing both impairments and activity limitations) of the CP condition.

The research hypotheses that guided the conduction of this study were (1) a significant association between CP subtypes and GMFCS-E&R levels would be found, and (2) there would be significant differences in distribution of impairments and activity limitation across CP subtypes and GMFCS-E&R levels. Consequently, the aims of this study were (1) to describe the relationship between CP subtypes and GMFCS-E&R levels; and (2) to examine differences in distribution of impairments (scoliosis, scissoring, and inability to bear weight on lower limbs), activity limitations (transfer and functional mobility) across GMFCS-E&R levels and CP subtypes.

PARTICIPANTS AND METHODS

Participants were recruited from the database of CPUP-Jordan registry for children and youth with CP which was established in 2013 with a national fund from the Scientific Research Support Fund¹⁵. Ethical approvals from the participant settings were obtained including the Institutional Review Board of the Ministry of Health and the Hospital of University of Jordan. Each participant provided an informed written parental consent to participate in the study.

A total of 70 children with CP participated in the study (mean age: 6.5 ± 2.9 years; range: 3–16 years). Inclusion criteria were: (1) a confirmed diagnosis of CP by a neuropsychiatrist, and (2) children 3 years of age or more. Exclusion criterion was concomitant health conditions such as autism or genetic disorders. The characteristics of participant children are shown in Table 1. Males were slightly more than females. Most of the children were in the spastic type of CP, 44.3% were with quadriplegia and the majority of children were in levels IV and V of the GMFCS-E&R.

The GMFCS-E&R was used to classify the children based on their gross motor abilities. It describes motor function for different age groups making it more relevant to the changing motor development of children with time. The GMFCS-E&R has a well-established reliability and validity⁹; with a clinician friendly description of each level (Table 2). The GMFCS-E&R was determined by trained research assistants.

The Functional Mobility Scale (FMS) was used to describe the children's functional mobility at home, school and community. The FMS rates child's walking ability at three specific distances 5, 50, and 500 meters representing the child's actual mobility at home, at school, and in the community settings. Rating is usually completed by parent report taking into account assistive devices used such as crutches, walker or wheelchair. The FMS has established reliability and validity¹⁶.

Data were collected by research assistants who completed two days' workshop on interviewing participant parents and conducting the measures of the study. The research assistants determined the CP subtype using standardized descriptions (Table 3), assessed children for the presence of impairments including: scoliosis, scissoring, and inability to bear weight on feet, completed the FMS and asked the parents about children's performance of functional activities including: floor sitting, chair sitting, sit to stand, standing, and stair climbing. The research assistants determined the GMFCS-E&R of the children based on observation and parents report.

Data were analyzed using the SPSS version 17 (SPSS Inc., Chicago, IL, USA). Descriptive analyses including frequency and cross tabulation were performed. Associations between the GMFCS-E&R and the CP subtypes were examined by calcu-

Table 1. Distribution of participant children based on CP subtypes and GMFCS-E&R levels (N=70)

GMFCS-E&R levels	I (N=7)	II (N=13)	III (N=7)	IV (N=26)	V (N=17)
Spastic diplegia	3 (42.9%)	6 (46.1%)	3 (42.9%)	8 (30.8%)	1 (5.9%)
Spastic quadriplegia	0 (0.0%)	4 (30.8%)	1 (14.2%)	11 (42.3%)	15 (88.2%)*
Spastic hemiplegia	4 (57.1%)*	3 (23.1%)	0 (0.0%)	3 (11.5%)	0 (0.0%)
Dyskinetic/athetosis	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (7.7%)	1 (5.9%)
Ataxic	0 (0.0%)	0 (0.0%)	3 (42.9%)	1 (3.8%)	0 (0.0%)
Mixed	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (3.8%)	0 (0.0%)

CP: cerebral palsy; GMFCS-E&R: Gross Motor Function Classification System-Expanded and Revised.

*Fisher's Exact Test, $p < 0.01$.

Table 2. Gross Motor Function Classification System-Expanded and Revised (GMFCS-E&R) –General descriptions of levels*

LEVEL I	- Walks without limitations
LEVEL II	- Walks with limitations
LEVEL III	- Walks using a hand-held mobility device
LEVEL IV	- Self-mobility with limitations; may use powered mobility
LEVEL V	- Transported in a manual wheelchair

*Palisano, R. J., Rosenbaum, P., Bartlett, D., & Livingston, M. H. (2007).

Table 3. Definitions of cerebral palsy subtypes

Spastic quadriplegia	Persistent increase in muscle tone in all four limbs.
Spastic diplegia	Persistent increase in muscle tone in both lower limbs more than upper limbs.
Spastic hemiplegia	Persistent increase in muscle tone in one half of the body more than the other half.
Dyskinesia	Varying tone accompanied with abnormal involuntary movement at rest (athetosis) or with movement (dystonia).
Ataxia	Abnormal pattern of posture and/or movement (abnormal force, rhythm or accuracy) with loss of muscle coordination.

lating χ^2 or Fisher's exact test (when expected frequencies in cells are less than 5). Distribution of impairments and activity limitations across levels of the GMFCS-E&R and subtypes of CP were also examined by χ^2 or Fisher's exact test (when expected frequencies in cells are less than 5). Significance level was set at $p < 0.05$.

RESULTS

The relationship between CP subtypes and the GMFCS-E&R levels is shown in Table 1. Level I included only children with diplegia and hemiplegia. Level II included children with spastic quadriplegia in addition to spastic diplegia and hemiplegia. Almost all children in level V were with spastic quadriplegia (88.2%). There was a significant association between CP subtypes and GMFCS-E&R levels, Fisher's Exact Test=40.88, $p < 0.001$. Children with hemiplegia were more in level I ($z=3$, $p < 0.01$); while there were more children with quadriplegia in level V ($z=2.7$, $p < 0.01$).

Distribution of impairments by GMFCS-E&R levels is presented in Table 4. Impairments were more prevalent in children classified in levels IV and V. The presence of scissoring at rest was significantly associated with GMFCS-E&R levels (Fisher's exact test=11.57, $p=0.01$). Specifically, there were more children who had scissoring at rest in level V ($z=2.7$, $p < 0.01$). Bearing weight on both feet was significantly associated with GMFCS-E&R levels (Fisher's exact test=22.22, $p < 0.001$). Specifically, there were less children who are not able to bear weight on both feet in level I ($z=-1.7$, $p < 0.05$) and more children who are not able to bear weight on both feet in level V ($z=2.8$, $p < 0.01$). The presence of scoliosis was significantly associated with GMFCS-E&R levels (Fisher's exact test=11.75, $p=0.015$) and with CP subtypes (Fisher's exact test=13.41, $p=0.008$). There were more children with scoliosis in level V ($z=2.1$, $p < 0.05$) and in the spastic quadriplegia subtype of CP ($z=1.6$, $p=0.055$).

CP subtypes were not significantly associated with other impairments (scissoring during walking, $p=0.239$; scissoring at rest, $p=0.172$; bearing weight on both feet, $p=0.058$).

Distribution of activity limitations by GMFCS-E&R is shown in Table 5. Limitations in transfer activities exhibited by children were significantly related to their GMFCS-E&R level. Children in level V were the most limited in transfer activities including: floor sitting ($z=4.8$, $p < 0.001$); chair sitting ($z=3.7$, $p < 0.001$); sit to stand ($z=4.8$, $p < 0.001$); standing

Table 4. Distribution of impairments by GMFCS-E&R levels (N=70)

CP characteristics	Scissoring during walking (of ambulant children)	Scissoring at rest	Bearing weight on both feet	Scoliosis
	n (%)	n (%)	n (%)	n (%)
GMFCS				
I (n=7)	1 (14.3)	0 (0.0)	7 (100.0)	1 (14.3)
II (n=13)	3 (23.1)	0 (0.0)	11 (84.6)	3 (23.1)
III (n=7)	3 (42.9)	1 (14.3)	3 (42.9)	0 (0.0)
IV (n=26)	4 (28.6)	4 (15.4)	18 (69.2)	9 (34.6)
V (n=17)	2 (100.0)	8 (47.1)	3 (17.6)	11 (64.7)

GMFCS-E&R: Gross Motor Function Classification System-Expanded and Revised.

Table 5. Distribution of children's activities by GMFCS-E&R levels (N=70)

GMFCS-E&R level (n)	I (7) n (%)	II (13) n (%)	III (7) n (%)	IV (26) n (%)	V (17) n (%)	p*
Floor sitting	7 (100.0)	13 (100.0)	7 (100.0)	20 (76.9)	0 (0.0)	0.001
Chair sitting	7 (100.0)	13 (100.0)	5 (71.4)	17 (65.4)	1 (5.9)	0.001
Sit to stand	7 (100.0)	13 (100.0)	7 (100.0)	20 (76.9)	0 (0.0)	0.001
Standing	7 (100.0)	13 (100.0)	7 (100.0)	21 (80.8)	0 (0.0)	0.001
Stair climbing	7 (100.0)	13 (100.0)	7 (100.0)	12 (46.2)	0 (0.0)	0.001

GMFCS-E&R: Gross Motor Function Classification System-Expanded and Revised.

* χ^2 test.

Table 6. Distribution of participant children across Functional Mobility Scale distances (FMS) (N=58)

FMS rating	5 m	50 m	500 m
Uses wheelchair	5 (8.6%)	11 (19.0%)	10 (17.2%)
Uses a walker or frame	3 (5.2%)	3 (5.2%)	0 (0%)
Uses sticks	3 (5.2%)	3 (5.2%)	2 (3.4%)
Independent on level surfaces	5 (8.6%)	7 (12.1%)	5 (8.6%)
Independent on all surfaces	8 (13.8%)	6 (10.3%)	4 (6.9%)
N, does not apply	13 (22.4%)	20 (34.5%)	35 (60.3%)
C, crawling	21 (36.2%)	8 (13.8%)	2 (3.4%)

($z=5$, $p<0.001$); and stair climbing ($z=3.5$, $p<0.001$). Transfer activities (floor sitting, chair sitting, sit to stand, standing, stair climbing) were also associated with CP subtypes ($p<0.05$). Limitations were significantly more pronounced in children with quadriplegia ($p<0.05$), specifically, children with quadriplegia did not assume floor sitting ($z=2.8$, $p=0.003$); chair sitting ($z=2.0$, $p=0.02$); sit to stand ($z=2.1$, $p=0.018$); standing ($z=2.3$, $p=0.01$); or stair climbing ($z=2.2$, $p=0.014$).

Functional mobility as measured by the FMS for children at three walking distances is shown in Table 6. Overall, most of the participant children used wheelchair for long distances (50 m and 500 m), while they used crawling for shorter distance (5 m) and none used crutches for ambulation in any of the walking distances. Moreover, many children did not have any form of mobility in the three distances.

Table 7 presents FMS by GMFCS-E&R levels. There were significant associations between GMFCS-E&R levels and FMS distances: FMS (5 m) $\chi^2(16)=90.28$, $p<0.001$; the FMS (50 m) $\chi^2(16)=75.19$, $p<0.001$; and the FMS (500 m) Fisher's exact test=51.928, $p<0.001$. Most of children in levels I and II were independent walkers without any walking aids in the three walking distances ($p<0.001$ to $p<0.05$). Children in levels III and IV usually crawled for short distances ($p=0.017$, $p=0.008$) and none were independent walkers. In addition, most of these children did not go out in the community (long distances). The majority of children in level V had no form of functional mobility in all three distances: of the seventeen children in our sample who were classified in level V, 13 did not move around at home (5 m), 14 did not move around at the school (50 m) and 15 did not move around at a 500 meter distance.

As for CP subtypes, there were significant associations between CP subtypes and the two walking distances: FMS (5 m), Fisher's exact test=44.08, $p<0.001$; and FMS (50 m), Fisher's exact test=30.96, $p<0.05$. However, CP subtypes and the

Table 7. Distribution of participant children based on FMS and GMFCS-E&R levels (N=58)

GMFCS-E&R levels	FMS rating	5 meter	50 meter	500 meter
I (N=4)	independent	4 (100.0%)	4 (100.0%)	4 (100.0%)
II (N=12)	uses wheelchair	0 (0.0%)	0 (0.0%)	3 (25.0%)
	uses a walking aid	3 (25.0%)	3 (25.0%)	2 (16.7%)
	independent	9 (75.0%)	9 (75.0%)	5 (41.7%)
	does not apply	0 (0.0%)	0 (0.0%)	1 (8.3%)
	crawling	0 (0.0%)	0 (0.0%)	1 (8.3%)
III (N=7)	uses wheelchair	0 (0.0%)	2 (28.6%)	1 (14.3%)
	uses a walking aid	1 (14.3%)	2 (28.6%)	0 (0.0%)
	does not apply	0 (0.0%)	1 (14.3%)	6 (85.7%)
	crawling	6 (85.7%)	2 (28.6%)	0 (0.0%)
IV (N=21)	uses wheelchair	3 (14.3%)	7 (33.3%)	5 (23.8%)
	uses a walking aid	2 (9.5%)	1 (4.8%)	0 (0.0%)
	does not apply	3 (14.3%)	8 (38.1%)	16 (76.2%)
	crawling	13 (61.9%)	5 (23.8%)	0 (0.0%)
V (N=14)	uses wheelchair	2 (14.3%)	2 (14.3%)	1 (7.1%)
	does not apply	10 (71.4%)	11 (78.6%)	12 (85.7%)
	crawling	2 (14.3%)	1 (7.1%)	1 (7.1%)

Ratings were compiled together to simplify presentation of data: Using walking aid includes (using a walker, crutches or sticks), independent includes independent walker on levelled and uneven surfaces. FMS: Functional Mobility Scale; GMFCS-E&R: Gross Motor Function Classification System-Expanded and Revised.

longest distance category (500 m) were not significantly associated, Fisher's exact test=27.45, $p=0.065$. Over all, at all levels of the FMS (5, 50, 500 m), there were more children with hemiplegia who walked independently ($z=2.1, 2.1, 3.0$ respectively, $p<0.05$).

DISCUSSION

This study aimed to examine associations between CP subtypes and GMFCS-E&R levels and differences in distribution of impairments and activity limitations based on CP subtypes and GMFCS-E&R levels in children with CP in Jordan. The first hypothesis was supported by the findings of the study in that both classifications were found to be significantly associated and related to impairments and functional limitations. Similar to previous studies¹⁰⁻¹² our results have shown that children with higher motor function of the GMFCS-E&R (level I and II) were mostly with spastic hemiplegia type; while children with quadriplegia were more in the lower motor function levels of the GMFCS-E&R (level IV and V). Obviously, CP subtypes and the GMFCS-E&R provide related yet different information about the child with CP. Therefore, a recommendation for researchers and clinicians is to use the two classifications when assessing and planning for services for children with CP to ensure that each child receives services that cover impairments and activity limitations components of the ICF model. The Arabic version of the GMFCS-E&R has been examined and shown to be reliable and easy to be used with Jordanian children with CP¹⁷) yet the GMFCS-E&R is not used by clinicians in sites that provide services for children with CP. Most recently, the GMFCS-E&R was administered as part of assessment for children with CP in the CPUP-Jordan registry¹⁵) with the aim to enhance this practice among pediatric physiotherapists in Jordan.

The findings of the study supported the second hypothesis in that significant differences in distribution of impairments and activity limitation were found across CP subtypes and GMFCS-E&R levels. More specifically, children with quadriplegia and those in levels IV and V on the GMFCS-E&R had more impairments (scoliosis and scissoring) and more limitations in transfers activities and functional mobility, whereas children with hemiplegia and diplegia were the least severely involved and had few impairments and functional limitations. Clinicians and service providers are encouraged to expand their horizon when planning services for children who are severely involved (i.e., children with quadriplegia, children in levels IV & V of the GMFCS-E&R) as they are at a higher risk of secondary impairments, functional limitations, participation restriction and social isolation. Services should be comprehensive and target specific needs of those children such as family counselling, and recommendations for adaptive equipment, assistive devices and environmental adaptations.

The functional mobility as measured by the FMS and the GMFCS-E&R were significantly associated in that most of children in levels I and II were independent walkers in all distances while most of children in level V had no form of functional mobility in different walking distances. FMS was also significantly associated with CP subtypes, albeit only at home and school (5 m and 50 m). The two classifications (CP subtype and GMFCS-E&R) can guide clinicians to predict

mobility needs and challenges faced by children with CP during mobility. For example, children with hemiplegia and those in levels I and II at the GMFCS-E&R were independent walkers in all walking environments. Shevell et al.¹⁸⁾ examined CP subtypes and GMFCS levels in a cohort of children with CP and found that CP subtypes can predict ambulation (as indicated by GMFCS) in children with CP. Most of children with spastic quadriplegia in their study were in levels IV and V, children with hemiplegia were in levels I and II, while children with diplegia were in levels I to III of the GMFCS-E&R. Therefore, the two classifications can be used as an easy and quick way to inform families about the child's expected ambulation outcomes.

Our findings showed that the use of wheelchair mobility is limited even in the severely involved children (GMFCS-E&R level V and quadriplegia). It seems that children and parents prefer crawling for short distances and not going out in the community rather than using wheelchair as a form of mobility. Suggested reasons might be parents' fear of the disability stigma, environmental inaccessibility or lack of financial resources. It was found in a previous study that, as children with CP grow, they stop receiving medical, educational and social services¹⁴⁾. This inaccessibility of services may be related, partly, to lack of wheeled mobility. Palisano et al.¹⁹⁾ have also found that social participation is related to ambulation status of children and youth with CP. Children with decreased functional mobility are at risk of isolation and decreased participation. The encouragement of use of wheeled mobility and other assistive devices may help these children to be better integrated within their local community. As indicated by the ICF, environmental factors can form barriers (inaccessibility and lack of resources) or be facilitators (adaptive equipment and mobility devices) to the child's functional abilities. Physiotherapists have a major role in providing consultations to families regarding mobility options for their children with an aim of improving participation.

The results of the study should be viewed in light of some limitations related to generalization of the results. Most of the participant children are of young age and representation of the young adult is limited. In addition, most of the participants are of severely limited mobility and in lower functional levels which might lead to bias in findings and underrepresentation of children with higher functional abilities. Since this study participants were recruited from hospital sittings, it will be important to include children with CP who receive services in school sittings.

In conclusion, CP subtypes and the GMFCS-E&R classifications are complementary and of a great help to guide clinicians in planning comprehensive and individualized care of children with CP. The use of both classifications in management of children with CP brings the focus of therapists not only to impairments, but also on activity limitations. The two classifications enable clinicians to provide counselling to families about expectations and services. Severe impairments are usually associated with severe activity limitations in children with CP leading to the risk of social isolation and disintegration. Therefore, clinicians are required to bring their attention to these children and provide necessary services to enhance mobility and participation.

Conflict of interest

Authors reported no conflict of interest.

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