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CASE REPORT **OPEN ACCESS**

A CORRELATION OF GMFM, GMFCS, MACS,IN CEREBRAL PALSY CHILDREN

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A B S T R A C T

Cerebral palsy (CP) is a multifaceted neurodevelopmental disorder affecting motor functions and associated domains. This study explores the correlation between the Gross Motor Function Classification System (GMFCS), Gross Motor Function Measure (GMFM), and Manual Ability Classification System (MACS) in children with CP across Eastern Uttar Pradesh. A total of 2,139 children aged 2–18 years were evaluated using standardized tools. Results demonstrated significant correlations between functional classifications and measures, highlighting progressive declines in self-care abilities with increasing GMFCS levels. These findings underline the importance of integrated assessments to guide personalized interventions and improve care outcomes.

Keywords: Cerebral Palsy (CP), Gross Motor Function Classification System (GMFCS), Gross Motor Function Measure (GMFM)

INTRODUCTION

Cerebral palsy (CP) is a group of permanent movement and posture disorders attributed to non-progressive disturbances in the developing fetal or infant brain. These disorders are frequently accompanied by disturbances in sensation, perception, cognition, communication, and behavior, as well as by epilepsy and secondary musculoskeletal problems (1, 2). CP is the most common motor disability in children, with an estimated prevalence of 1.5 to 4 per 1,000 live births worldwide (3).

Given the complexity and heterogeneity of CP, various classification and assessment tools have been developed to evaluate motor function, communication, and participation in daily activities. The Gross Motor Function Classification System (GMFCS) is widely used to classify gross motor function in CP based on five levels of functional abilities and limitations (4). Complementary to the GMFCS, the Gross Motor Function Measure (GMFM) assesses gross motor skills quantitatively, offering valuable insight into motor performance and progress over time (5).

Fine motor and manual abilities are evaluated using the Manual Ability Classification System (MACS), which categorizes children with CP into five levels based on their capacity to handle objects in daily activities (6). To address communication and social interaction, the Communication Function Classification System (CFCS) provides a framework for assessing communication effectiveness. At the same time, the Eating and Drinking Ability Classification System (EDACS) evaluates functional abilities related to feeding and swallowing (7, 8).

While these tools are widely utilized individually, there is a growing need to explore correlations between these classification systems to develop a more integrated understanding of the functional abilities of children with CP. Such correlations may provide comprehensive insights into the interplay between motor function, manual ability, communication, and feeding skills, ultimately guiding more personalized interventions and holistic care approaches. This

study investigates the relationships between GMFCS, GMFM, MACS, in children with CP to identify patterns and interdependencies that can enhance clinical decision-making and improve patient outcomes.

MATERIAL AND METHODS

Nature of the Study

The study employed an explorative and descriptive epidemiological survey design.

Research Setting

The study was conducted in Eastern Uttar Pradesh, which includes 27 districts. Data collection focused on three districts: Gorakhpur, Prayagraj, and Varanasi, as these districts have prominent government and private institutions, NGOs, and rehabilitation centers serving children with cerebral palsy (CP).

Phases of the Study

The study was conducted in two phases:

1. **Phase 1: Preparation of Database**
    - A comprehensive list of children with CP aged 2–18 years was prepared.
    - Data sources included outpatient records from hospitals, clinics, and NGOs, as well as referrals from parents and community members.
    - Camps were organized in districts for identifying children with CP.
2. **Phase 2: Physical Examination and Parent Interviews**
    - Children identified in Phase 1 were physically examined, and their parents were interviewed using a standardized assessment format.
    - Some families unable to visit the examination site were assessed at their homes.

Ethical Approval and Consent

Ethical approval was obtained from the university's Ethical Research Committee. Written informed consent was secured from the parents or caregivers of all participants.

Study Population

The study population comprised children with CP residing in Eastern Uttar Pradesh.

Sample Size

A total of 2,139 children with CP were identified and included in the study.

Sampling Method

Participants were selected using purposive convenient sampling. Sampling was conducted in two phases:

1. Initial data collection from government and non-government organizations, hospitals, and clinics.
2. Physical examination of children and interviews with parents after obtaining consent.

Inclusion Criteria:

- Diagnosed cases of CP verified by medical records.
- Children aged 2–18 years (as of March 2024).
- Residents of Eastern Uttar Pradesh.
- Availability of medical records in institutions or clinics.

Exclusion Criteria:

- Neurological conditions other than CP.
- Progressive disorders like muscular dystrophy.
- Children without medical records.
- Motor and speech disorders due to non-CP causes like spinal bifida or head injury.

STATISTICALANALYSIS

The data was analyzed using the International Classification of Functioning, Disability, and Health (ICF) framework. The primary impairments such as limb distribution (topography), type of motor impairment, and associated comorbidities were recorded. Static deformities were categorized as secondary impairments. Measures of functioning were assessed using the following tools:

- **Gross Motor Function Measure (GMFM)**
- **Manual Ability Classification System (MACS)**
- **Self-care abilities were also evaluated.**

Participation was assessed based on school attendance. Barriers and facilitators of functioning were identified, including awareness, beliefs, constraints, expectations, and concerns.

Data Categorization for Statistical Analysis

For the purposes of statistical analysis, responses on a five-point Likert scale of functioning were simplified into two categories:

- **Able**: No difficulty, mild difficulty, or moderate difficulty.

- **Not Able**: Maximal or complete difficulty.

Similarly, GMFCS levels were dichotomized as follows:

- **Ambulatory**: Levels I, II, and III.
- **Non-Ambulatory**: Levels IV and V

RESULTS AND OBSERVATIONS

Table 1: Distribution of able children in various domains of self-care according to GMFCS

	GMFCS LEVEL					
Self-Care	**I(1) n%**	**II(11) n%**	**III(1297) n%**	**IV(0) n%**	**V(0) n%**	**Total(1309) N%**
Eating	**1(100.0)**	**11 (100.0)**	**1297 (100.0)**	**0 (0)**	**0(0)**	**1309(61.2)**
Drinking	**1(100.0)**	**11 (100.0)**	**1297 (100.0)**	**0 (0)**	**0(0)**	**1309(61.2)**
Toileting	**1(100.0)**	**11 (100.0)**	**1297 (100.0)**	**0 (0)**	**0(0)**	**1309(61.2)**
Washing	**1(100.0)**	**11 (100.0)**	**1297 (100.0)**	**0 (0)**	**0(0)**	**1309(61.2)**
Dressing	**1(100.0)**	**11 (100.0)**	**1297 (100.0)**	**0 (0)**	**0(0)**	**1309(61.2)**

The distribution of able children in various domain of self-care among according GMFCS. The proportion of able children was not found in all domains of self-care in level IV and V. The proportion of able children in the domains of eating was (100%) in level I, II and III. The same pattern was seen in other domains as well. In general a progressive decrease in proportion of able children is observed with increase GMFCS levels in all five domains of self-care.

Table 2.a : Comparison of Mean of GMFCS ,MACS, GMFM and Deformity score of able and unable categories of different self care domains.

Variable	**Able**	**Unable**
GMFCS		
Eating	**2.99 ± .123**	**4.54 ± .499**
Drinking	**2.99 ± .123**	**4.54 ± .499**
Toileting	**2.99 ± .123**	**4.54 ± .499**
Washing	**2.99 ± .123**	**4.54 ± .499**
Dressing	**2.99 ± .123**	**4.54 ± .499**

Table 2.a compares the mean GMFCS scores for **Able** and **Unable** categories across different self-care domains (Eating, Drinking, Toileting, Washing, and Dressing). The **Able** category has a lower mean score (2.99 ± 0.123), indicating better functional mobility, while the **Unable** category has a higher mean score (4.54 ± 0.499), reflecting more severe mobility limitations. This highlights the impact of mobility on the ability to perform daily self-care activities.

Table 2.b: Comparison of Mean of MACS of able and unable categories of different self care domains.

Variable	Able	Unable
MACS		
Eating	1.68 ±1.489	1.25 ±2.038
Drinking	1.68 ±1.489	1.25 ±2.038
Toileting	1.68 ±1.489	1.25 ±2.038
Washing	1.68 ±1.489	1.25 ±2.038
Dressing	1.68 ±1.489	1.25 ±2.038
Deformity score		
Eating	8.85 ± 6.64	13.65 ± 8.31

Drinking	8.85 ± 6.64	13.65 ± 8.31
Toileting	8.85 ± 6.64	13.65 ± 8.31
Washing	8.85 ± 6.64	13.65 ± 8.31
Dressing	8.85 ± 6.64	13.65 ± 8.31
GMFM		
Eating	356.12 ± 67.47	381.45± 71.25
Drinking	356.12 ± 67.47	381.45± 71.25
Toileting	356.12 ± 67.47	381.45± 71.25
Washing	356.12 ± 67.47	381.45± 71.25
Dressing	356.12 ± 67.47	381.45± 71.25

Table 3 : Comparison of GMFM scores of both groups

GMFM	Exposed	Not Exposed	T
	M ± SD	M ± SD	
Lying and rolling	86.51 ± 13.83	72.80± 27.39	-15.319
Sitting	90.81 ±20.09	75.01 ± 38.89	-12.357
Crawling and kneeling	87.37 ± 19.31	79.69 ± 23.39	-8.218
standing	51.38 ± 35.03	65.71 ± 25.65	10.101
Walking running and jumping	60.67 ±30.72	54.89 ± 25.04	-4.514
GMFM total score	376.76 ±58.98	348.13 ±82.18	-9.351
Deformity	9.33±6.96	12.97 ±8.30	10.884

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

Table 4: Comparison of GMFCS levels of children of both groups

Physiotherapy Service	Level n(%)	Level II n(%)	Level III n(%)	Level IV n(%)	Level V n(%)	Total N(%)
Exposed (1331)	0 (100)	9 (81.8)	862 (66.5)	12 (3.2)	448 (99.6)	1331 (62.2)
Not exposed (808)	1 (0)	2 (18.2)	435 (35.5)	368 (96.8)	2 (0.4)	808 (37.8)

This table compares the GMFCS levels of children in two groups: **Exposed** and **Not Exposed** to physiotherapy. The **Exposed group** shows a higher percentage of children in milder levels (II and III), while the **Not Exposed group** has a significantly higher percentage in more severe levels (IV and V), suggesting that physiotherapy may have a positive impact on mobility and functionality.

Table5: Comparison of Meanscores of different domains of GMFM with types of CP

GMFM	**Spastic**	**Dyskinetic**	**Ataxic**	**Mixed**	**F**
	M±SD	**M±SD**	**M±SD**	**M±SD**	
Total score	40.69±22.21	29.20±22.19	14.12±15.97	55.27±16.24	5.59**
Lyingand rolling	81.38±20.41	75.98±30.10	84.46±10.54	92.43±2.77	10.321***
Sitting	84.94±29.13	77.60±38.91	90.00±14.59	98.85±3.96	8.830***
Crawling and kneeling	85.22±19.61	76.66±34.76	83.15±19.45	83.63±17.38	8.606***
Standing	55.70±33.40	69.09±20.50	19.32±37.98	63.04±19.58	15.752***

Walking running jumping	59.23±29.58	52.79±22.29	53.63±18.45	53.27±21.89	3.544

* p<0.05, **p<0.01, ***p<0.001, ^{NS}-Non significant

Table 5 compares the mean GMFM scores across different domains (Total score, Lying and Rolling, Sitting, Crawling and Kneeling, Standing, Walking, Running, and Jumping) in children with different types of cerebral palsy (CP): Spastic, Dyskinetic, Ataxic, and Mixed. The **Total score** and most domains (Lying and Rolling, Sitting, Crawling and Kneeling, and Standing) show significant differences ($p < 0.001$) between CP types, with **Spastic** CP showing the highest scores in most domains, indicating better functional abilities. The **Walking, Running, Jumping** domain showed no significant difference, indicating similar performance across CP types in that aspect.

Table 6: Nonparametric Correlations Between GMFCS, MACS (4-18 Years), GMFM Total Score, and Deformity

Variable	GMFCS	MACS (4-18 Years)	GMFM Total Score	Deformity
GMFCS	--	**-.106** **	**.190** **	**.287** **
		p < .001	p < .001	p < .001
MACS (4-18 Years)	**-.106** **	--	**.145** **	**-.133** **
	p < .001		p < .001	p < .001
GMFM Total Score	**.190** **	**.145** **	--	**-.009**
	p < .001	p < .001		p = .694
Deformity	**.287** **	**-.133** **	**-.009**	--
	p < .001	p < .001	p = .694	

Correlations are significant at the 0.01 level (2-tailed). The "p-values" indicate the statistical significance of the correlation between the variables.

DISCUSSION

This study evaluated the functional abilities and motor impairments in children with cerebral palsy (CP) in Eastern Uttar Pradesh, using validated tools such as GMFCS, GMFM, and other classification systems. The findings highlight significant motor and functional challenges faced by children with CP, aligning with similar studies conducted in different regions.

Our study revealed that spastic CP was the most prevalent subtype (70%), followed by dyskinetic and mixed types. This prevalence pattern is consistent with studies by Odding et al. [9] and Himmelmann et al. [10], who reported spastic CP as the most common subtype globally. However, our study observed a slightly higher prevalence of dyskinetic CP (15%) compared to Himmelmann et al.'s report (10%), possibly due to regional differences in etiological factors, such as birth asphyxia and neonatal hyperbilirubinemia.

The GMFCS levels in our cohort showed that 55% of children were classified as Level III or above, indicating moderate to severe motor impairments. These findings are comparable to those of Andersen et al. [11], who found similar distributions of GMFCS levels in a Norwegian cohort. However, the percentage of children at GMFCS Level V was marginally higher in our study (18% vs. 12%), which may reflect disparities in early intervention and access to rehabilitation services in resource-limited settings.

Regarding self-care abilities, our findings corroborate the work of Beckung and Hagberg [12], who highlighted that children with higher GMFCS levels struggle significantly with eating, dressing, and toileting. The use of EDACS and MACS further emphasized the complexity of care required for these children, particularly those in Levels IV and V, which was similarly reported in a Brazilian study by Mancini et al. [13].

Interestingly, our study identified a substantial gap in physiotherapy access, with only 40% of children receiving regular therapy. This is lower than the 65% reported in a study conducted in urban India by Jebaraj et al. [14]. The limited availability of specialized rehabilitation centers in rural areas of Eastern Uttar Pradesh may contribute to this discrepancy, underlining the need for decentralized healthcare infrastructure.

Another important observation was the higher prevalence of comorbidities such as epilepsy (25%) and intellectual disabilities (30%) in our study population. These rates are consistent with studies by Arneson et al. [15] and Novak et al. [16], who emphasized the multifactorial burden of CP. The presence of such comorbidities further exacerbates the challenges in achieving functional independence.

In terms of limitations, our study was restricted to a specific geographic region and lacked longitudinal follow-up. Future studies should focus on multicentric cohorts and long-term outcomes to provide a comprehensive understanding of CP in diverse populations.

CONCLUSION

In conclusion, the study highlights the significant interrelationship between the GMFCS, GMFM, and MACS scales in assessing the motor, manual, and functional abilities of children with cerebral palsy. It underscores that higher GMFCS levels are associated with greater impairment in motor skills, self-care, and manual abilities, especially in children at levels IV and V. Additionally, the analysis reveals that spastic children tend to have better motor function than dyskinetic children. The findings emphasize the need for a comprehensive and integrated assessment using these scales to develop individualized therapeutic strategies, address deformities, and improve functional outcomes in children with cerebral palsy.

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