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Correlation and Prediction of GMFM-88 Scores with GMFCS Levels among Children with Cerebral Palsy in Palestine: A Cross-Sectional Study

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Abstract: ***This cross-sectional study investigated the relationship between Gross Motor Function Measure-88 (GMFM-88) scores and Gross Motor Function Classification System (GMFCS) levels among 50 children with cerebral palsy aged 4–12 years attending pediatric rehabilitation centers in Hebron, Bethlehem, and Jerusalem. The findings demonstrated a strong and statistically significant negative correlation between GMFM-88 total and domain scores and GMFCS levels ($\rho = -0.909$, $p < 0.001$), indicating that children with higher gross motor function scores were more likely to be classified in lower GMFCS levels, reflecting less severe motor impairment. All GMFM-88 domains showed significant negative correlations with GMFCS levels, with the strongest associations observed in the Walking, Running, and Jumping and Standing domains, highlighting the critical role of higher-level motor skills in differentiating functional severity among children with cerebral palsy. The results confirm a clear inverse relationship between motor performance and severity classification, emphasizing the clinical value of GMFM-88 in functional assessment and rehabilitation planning. This study is considered original as it provides one of the first empirical investigations in Palestine examining the association between GMFM-88 domain-specific scores and GMFCS levels, offering locally relevant evidence to support clinicians in evaluating motor function severity and designing targeted rehabilitation interventions for children with cerebral palsy.***

Keywords: Cerebral Palsy; GMFM-88; GMFCS Gross Motor Function, Functional Mobility; Cross-Sectional Study.

1. Introduction

Cerebral palsy (CP) is the most common cause of childhood physical disability worldwide. CP is a collection of movement and posture problems that are the result of permanent, non-progressive, damage to the developing brain. Children that are diagnosed with CP may experience a range of problems, suc h as spasticity, muscle loss, and poor control and coordination. These problems, which are all closely linked to each other, result in the child being unable to perform movement functions and control their movement independently [1]. CP is a prevalent condition around the world, occurring at a rate of 1.5 to 3 for every 1,000 children born. Reports from Palestine show averages that are about the same as this [2]. It is one of the most common causes of children being unable to control their movements and is the main reason that children are admitted into rehabilitation centers. It affects the child's ability to perform daily activities (ADL), increases the burden on the child's parents, and requires a long period of multidisciplinary collaboration in order to manage the condition [3].

Accurate classification and assessment of motor severity are essential for developing individualized rehabilitation plans. The Gross Motor Function Measure-88 (GMFM-88) is a standardized tool to quantify gross motor function in children with CP, while the Gross Motor Function Classification System (GMFCS) classifies the severity of functional motor performance in children with CP [1].

The Gross Motor Function Measure-88 (GMFM-88) is a standardized tool to measure changes in gross motor function in children with CP. It includes five dimensions of gross motor function: (A) Lying and Rolling, (B) Sitting, (C) Crawling and Kneeling, (D) Standing, and (E) Walking, Running, and Jumping [4].

The Gross Motor Function Classification System (GMFCS) includes a five-level ordinal classification system to describe the typical motor function in daily activities in children with CP. The levels range from I to V, including independent walking without any limitations to using a wheelchair with head and trunk support, respectively [4].

1.1 Problem Statement

The clinical application of the GMFM 88 and GMFCMs tool is that these two tools complement each other. The GMFM-88 tool provides specific quantitative information about the motor function of children with CP, while the GMFCS tool provides a more general classification of the severity of motor function in children with CP. The GMFM-88 tool takes a long time to administer in clinical settings [1].

The scores in GMFM-88 (total and domains) may be able to predict GMFCS levels (child's motor severity) could be extrapolated. This study would to asses if GMFM 88 tool can be considered as a predictive tool and ease the burden of performing extensive assessments on children and clinicians and if GMFM-88 scores correlate with levels of GMFCS I–V. This could ease the burden of assessments, and increase the accuracy of the prognosis and the planning of

rehabilitation.

In addition, there is a clear gap in the existing literature regarding this topic. Only a limited number of studies have examined the relationship between GMFM-88 scores and GMFCS levels, and many of the available studies focus on only one or two GMFM-88 domains rather than the full assessment. Furthermore, to the best of the researcher's knowledge, there are very little few studies conducted in Palestine addressing this relationship, which highlights the need for local evidence.

1.2 Research Questions

- How well do GMFM-88 total scores predict the corresponding levels (I–V) of the GMFCS in children with cerebral palsy?
- Which GMFM-88 domains are most strongly associated with GMFCS levels I–V?

1.3 Hypothesis of the Study

H1:GMFM-88 total score and domain scores significantly predict GMFCS levels (I–V) among children with cerebral palsy.

H2: Higher GMFM-88 scores are associated with lower GMFCS severity (I–II), while lower scores are associated with higher severity (IV–V).

H3: There is no significant predictive relationship between GMFM-88 scores and GMFCS levels.

1.4 Objectives of the Study

- To assess the predictive validity of the GMFM-88 total scores for classifying GMFCS levels I to V in children with CP.
- To determine which GMFM-88 domains contribute most to prediction.
- To propose clinically useful cutoff scores for distinguishing among GMFCS levels.
- To provide recommendations for incorporating routine clinical assessment using GMFM-88 scoring.

This study will ease the classification of motor severity to assist in individualized therapy planning. In addition to that, it will establish predictive relationships and cutoff scores between GMFM-88 and GMFCS levels I-V.

Finally, it will facilitate better understanding of functional abilities and rehabilitation expectations. Moreover, Accurate early classification helps families understand a child's functional potential and thus to set realistic goals, thereby improving engagement in therapy.

2. literature review

Cerebral palsy (CP) is a group of permanent neurological disorders that affect movement, muscle tone, posture, and coordination. It results from damage to the developing brain, usually before birth, during birth, or shortly after birth. CP is non-progressive, meaning the brain injury does not worsen over time, although symptoms may change as the child grows. [5]. CP is commonly classified based on the type of movement disorder and the parts of the body affected [5].

Spastic cerebral palsy is the prevalent form accounting for approximately 70–80% of cases. It is characterized by increased muscle stiffness, spasticity, exaggerated reflexes and diminished motor abilities. Children with CP often face difficulties with movement, muscle weakness and gait abnormalities such, as scissoring gait or toe walking gait [6]. The second type is Dyskinetic cerebral palsy is marked by motions that disrupt motor functions. These children may have jerky motion (athetosis) or (chorea) in addition to prolonged twisting positions (dystonia). Muscle tone in dyskinetic CP varies with increased muscle tone (rigidity). Children affected by this form, commonly face challenges with posture control, speech and feeding although cognitive abilities may remain relatively intact in some instances. The third type is ataxic cerebral palsy is a type mainly marked by challenges in balance, coordination and spatial judgment. Kids with CP frequently display a wide based walk shaking when performing walking and face problems with precise motor skills. Usually motor coordination and skill acquisition suffer more than muscle strength or muscle tone[6]. And lastly, there is Mixed CP, which is a cerebral palsy that manifests with a combination of more than one type of cerebral palsy, most frequently a combination of spastic and dyskinetic cerebral palsy (athetoid/dystonic). More functional challenges are encountered, and a multidisciplinary therapeutic approach is required.

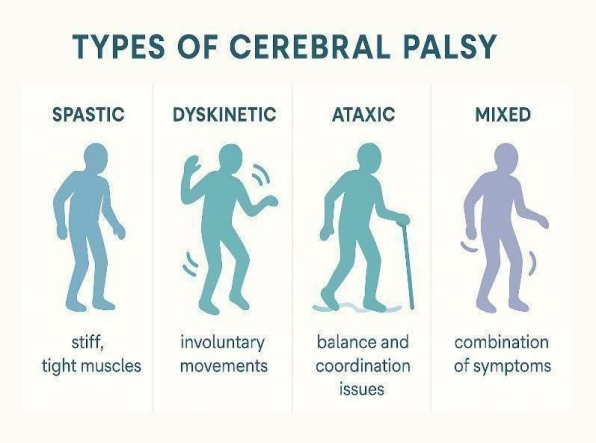

Figure 1: Types of CP

Areas of brain affected according to the type of cp

Spastic Cerebral Palsy

Spastic CP occurs due to the involvement of the primary motor cortex, premotor cortex, and corticospinal tracts. This usually happens due to periventricular white matter injury, also known as periventricular leukomalacia, especially in premature babies. This leads to spasticity, hyperreflexia, weakness, and poor selective motor control due to the involvement of the upper motor neurons. The localization of spastic cerebral palsy depends on the areas of the brain affected and the degree of involvement, resulting in spastic hemiplegia, diplegia, and quadriplegia.[7].

Dyskinetic Cerebral Palsy

Dyskinetic CP is associated with lesions in the basal ganglia, particularly the globus pallidus, and the thalamus.

These brain lesions often involve hypoxic-ischemic

encephalopathy or bilirubin neurotoxicity (kernicterus). The disruption of the extrapyramidal system causes involuntary movements and difficulties in muscle tone and postural control.

Dyskinetic CP is further divided into dystonic CP, which is characterized by sustained muscle contraction and abnormal postures, and athetoid CP, which is associated with slow and writhing movements that worsen with voluntary movements [8].

Ataxic Cerebral Palsy

Ataxic CP arises from damage to the cerebellum and its afferent and efferent connections, which are essential for motor coordination, balance, and movement timing. Cerebellar injury leads to ataxia, dysmetria, intention tremor, and impaired balance control. Children typically demonstrate a wide-based gait, poor postural stability, and difficulty with fine motor precision. Muscle tone is usually reduced or near normal, but movement quality is markedly uncoordinated [9].

Mixed Cerebral Palsy

Mixed CP occurs when multiple neural structures are involved, most commonly a combination of the motor cortex, basal ganglia, and cerebellum. This results in overlapping motor features, such as spasticity combined with dystonia or ataxia. Mixed CP is often associated with diffuse or severe brain injury, including extensive hypoxic–ischemic damage, and is characterized by complex functional limitations requiring multidisciplinary management [8].

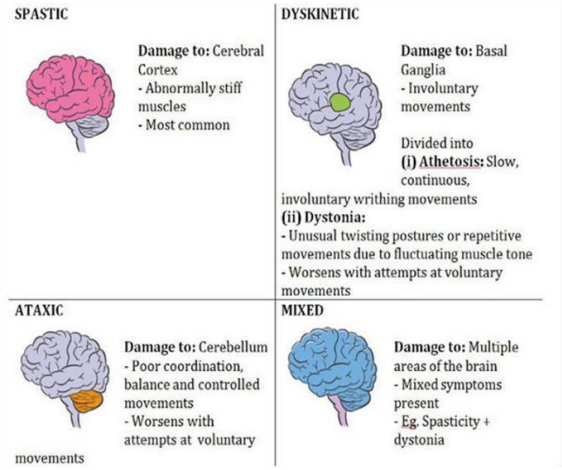

Figure 2: Areas of brain affected according to the types of cp

Distribution of Motor Impairments

Apart from classifying by motor type of cerebral palsy is also sorted based on the spread of motor dysfunction indicating the affected body areas and strongly linked to functional results.

Hemiplegia CP is characterized by motor impairment affecting one side of the body, with the upper limb typically more involved than the lower limb. Most children with hemiplegic CP achieve independent ambulation; however, they often demonstrate asymmetrical motor control and difficulties with bilateral coordination. The greater involvement of the upper limb commonly interferes with fine motor performance and functional activities of daily living, such as dressing, handwriting, and object manipulation. [10]

Diplegic CP is characterized by predominant involvement of the lower extremities, while the upper extremities are less severely affected. This presentation is most commonly linked with periventricular leukomalacia in the white matter of the brain, which is usually related to prematurity or perinatal hypoxia-ischemia [8]. Children with diplegia present with gait instability, poor postural control, and imbalance, which require them to use orthotic devices. These limitations in motor skills can further influence their functional mobility and performance of ADLs.

Quadriplegic CP: Cerebral palsy is associated with an impairment of all four limbs and the trunk. The upper limbs are more impaired than the lower limbs. The above is associated with the highest motor impairments and is usually linked to higher levels of GMFCS (IV to V).

Children with Quadriplegic CP usually have high levels of mobility limitations. They usually require assistance from caregivers to perform transfers, ambulation, and ADLs. Associated comorbidities include intellectual disability, epilepsy, and feeding difficulties.

The term tetraplegia is often used interchangeably with quadriplegia, sometimes emphasizing more extensive involvement of the trunk and head [11].

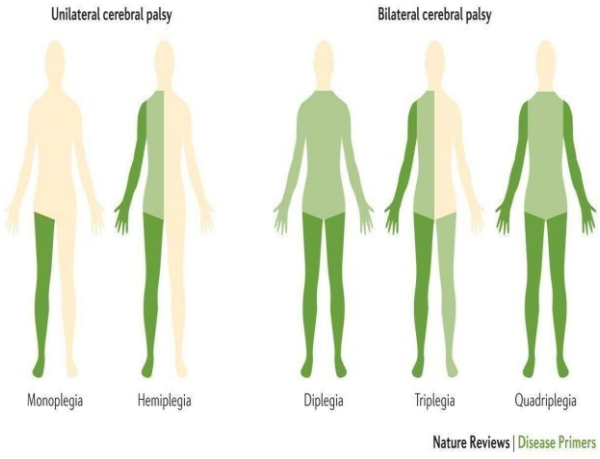

Figure 3: Distribution of Motor Impairments

Assessment of gross motor function in CP is central to clinical management and long-term prognosis. Assessment tools should be reliable, valid, and sensitive to change, and practical for use in the real clinical world. The GMFM 88 and GMFCS levels are probably the most widely used tools internationally among CP children [1].

The Gross Motor Function Measure (GMFM-88) is a standardized tool designed to measure changes in gross motor function in children with CP. It evaluates performance across five domains: (A) Lying and Rolling, (B) Sitting, (C) Crawling and Kneeling, (D) Standing, and (E) Walking, Running, and Jumping. The GMFM-88 has been widely validated for reliability, sensitivity, and responsiveness to therapeutic interventions. Each item is scored on a 4-point ordinal scale (0 = does not initiate, up to 3 = completes the task) [12].

The GMFM-88 has been found to have excellent inter-rater and intra-rater reliability. And it shows good responsiveness (sensitivity to changes over time) in follow-up assessments [13].

These results suggest that the GMFM-88 is a powerful tool for measuring gross motor function of individuals with varying forms of CP.

Gross Motor Function Classification System (GMFCS): This system is an ordinal scale of five levels, which defines the typical motor function of a child. It defines the motor function of a child based on their ability to perform motor functions in daily life. It ranges from independent walking without limitations to wheelchair user with head and trunk support. It has five levels:

- Level I: Walks without limitations,
- Level II: Walks with limitations (difficulty with long distances, balancing, and running/jumping),
- Level III: Walks with a hand-held mobility,
- Level IV: Wheelchair user,
- Level V: Wheelchair user with head and trunk support. [4].

The Gross Motor Function Classification System (GMFCS) is an ordinal scale with five levels, aiming to classify the child's usual gross motor function in daily activities rather than their best possible function [14]. Level I comprises children who walk independently in all environments, such as home, school, and community, and who can climb stairs without the support of a handrail. They also exhibit advanced motor skills, such as running and jumping, even though there is some limitation in speed, balance, and coordination. Level II comprises children who walk independently but with noticeable limitations. They often require handrails to climb stairs, experience difficulties on uneven surfaces, slopes, and in crowded and long distances, and exhibit limitations in running and jumping. Level III comprises children who walk with hand-held mobility aids such as walkers, crutches, and canes. They can walk short distances indoors but usually require wheelchairs for longer distances and outdoor activities. They require assistance to climb stairs.Level IV represents children with significantly limited self-mobility, even with assistive devices; these children primarily use manual or powered wheelchairs for mobility, and independent walking is rare and limited to very short distances with substantial physical support. Level V describes children with the most severe gross motor impairments, who are completely dependent on others for mobility, have limited voluntary control of head and trunk posture, and require extensive assistive technology, including adapted seating and manual or powered wheelchairs, to achieve mobility. The GMFCS is widely used in clinical practice and research to classify motor severity, guide intervention planning, and facilitate communication among healthcare professionals in the management of children with cerebral palsy [14].

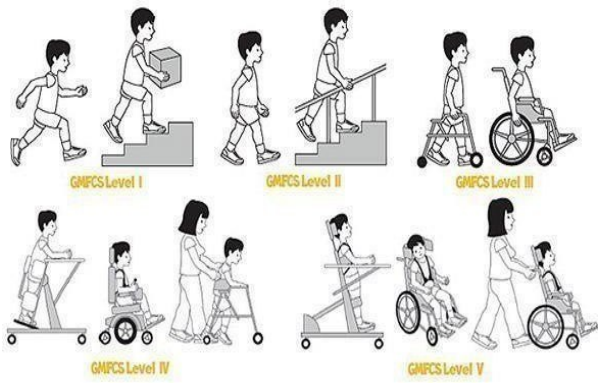

Figure 4: GMFCS levels

This study is based on the quantitative gross motor performance of (GMFM-88) which contains enough information to predict functional classification (GMFCS), because the GMFCS is partially determined by the child's capacity in gross motor tasks-especially standing and walking. This idea is in line with classification theory in rehabilitation, where measures of performance can be translated into functional categories in order to guide prognosis and intervention.

Several studies have investigated the relationship between gross motor function, functional classification, and motor performance in children with cerebral palsy (CP), mainly using the Gross Motor Function Measure (GMFM) and the Gross Motor Function Classification System (GMFCS).

A previous study developed and validated a nonlinear model describing gross motor development in children with CP across the five GMFCS levels. Their findings demonstrated a strong negative correlation ($r = -0.91$) between GMFCS levels and GMFM scores, indicating that higher GMFCS levels are associated with lower gross motor function. The study revealed that GMFCS-based classification is a strong predictor of motor function, while the age alone is a weak predictor. Definite developmental curves and maximum GMFM scores for each GMFCS level validated the clinical meaning of GMFCS distinctions[15].

Previous research extended this work by doing longitudinal gross motor development curves based on GMFM evaluations across GMFCS levels. The findings showed obvious differences in the rate and limit of motor development related to severity. Most children were approximately 90% of their gross motor potential by around 5 years of age, depending on GMFCS level, expressing the significance of early prognostic counseling and intervention planning[16].

Similarly, investigated the prognostic value of GMFM in assessing CP severity. Their longitudinal data proved momentous differences in developmental limits between GMFCS levels. Children with less motor potential reached their functional limits earlier, encouraging the use of GMFM and GMFCS for severity assessment, prognosis, and clinical management planning[17].

A study inspected the relationship between GMFCS levels and multiple outcome measures in ambulatory children with CP [18]. Strong correlations were noticed between GMFCS level and GMFM dimensions D (standing) and E (walking, running, jumping). Logistic regression analysis expressed that GMFM dimension E

could predict GMFCS level with 76.6% accuracy, aiding the validity of GMFCS as a functional classification system in clinical and research settings [18].

A study examined the association between motor capacity (GMFM) and motor performance (physical activity) in school-aged children with CP Children with GMFCS level I necessarily had higher motor capacity and physical activity than those with levels II and III. In addition, %MVPA was positively correlated with GMFM-66 in children with GMFCS levels II and III, which examined the interface of functional capacity with real-life motor acts [5].

With studies, there was evidence of a strong relationship between the levels of GMFCS and GMFM scores, further emphasizing the strength of GMFCS as a predictor of functional severity in CP. GMFM is not only useful in assessing the motor function of children with CP, but it can also be used in predicting their developmental paths. Correlation and regression analyses across these studies emphasize that functional classification provides more clinically relevant information than age alone.

3. Methodology

3.1 Study Design

A correlation cross-sectional analytical design is proposed to test the predictive association between the GMFM-88 scores and GMFCS levels I to V at a particular point in time among all types of cerebral palsy children.

3.2 Study Setting

Data was collected from pediatric rehabilitation centers, Al-Khalil Charitable Rehabilitation Society Hebron, Maccabi Health Services-Jerusalem, Adam's Therapy Rehabilitation Center Bethlehem, Jemina Organization for Mentally Handicapped Children

3.3 Study Population

Children with cerebral palsy receiving rehabilitation services in Palestine and including different levels of functional ability. Children whose parents agreed to participate in the study.

The participants were recruited from Al-Khalil Charitable Rehabilitation Society in Hebron, Maccabi Health Services in Jerusalem, Adam's Therapy Rehabilitation Center in Bethlehem, and Jemima Organization for Mentally Handicapped Children. Different levels of functionality (GMFCS Levels I– V) were included to enable comparison between GMFM-88 scores and GMFCS levels.

Inclusion Criteria:

Children aged 4–12 years with a confirmed diagnosis of cerebral palsy. Medically stable and able to participate in gross motor assessment.

Parental/guardian consent obtained.

Exclusion Criteria:

Children whose profound cognitive impairments preclude them from participating in an assessment.

Recent orthopedic surgery or botulinum toxin injection (<6 months).

3.4 Sample Size

A target of 50 participants is proposed.

3.5 Sampling Technique

Eligible participants were randomly recruited from participating rehabilitation centers. Physiotherapists and clinicians at each site will screen and identify children who meet the inclusion criteria. Recruitment will continue until the predetermined sample size is reached.

3.6 Study Variables

- Independent Variables: GMFM-88 total score and domain scores (A–E).
- Dependent Variable: GMFCS level (I-V).
- Covariates: Age, sex, CP subtype (spastic, dyskinetic, ataxic, mixed), use of assistive devices.
- Outcomes: Predictive Accuracy (Sensitivity, Specificity), Cut-off Values

3.7 Data collection tools

Gross Motor Function Measure – 88 (GMFM-88)

- Purpose: To assess gross motor function in children with cerebral palsy (88 items).
- Type: Standardized quantitative tool.
- Validity & Reliability: Valid and reliable internationally; results are consistent between raters and over time[16].

Gross Motor Function Classification System (GMFCS)

- Purpose: To classify gross motor performance of children with cerebral palsy into 5 levels (from independent to highly dependent).
- Type: Ordinal classification tool.
- Validity & Reliability: Valid and reliable after training; correlates with GMFM-88 scores. [16].

3.8 Data Collection Procedures

For data collection, all participating students were trained to assess the children using the same standardized protocols for each tool. This approach ensured that measurements were consistent and comparable across all participants.

Obtain approval from the institutional review board and clinical authorities. In addition, explain the study aims and procedures after written informed consent has been obtained from the parents/guardians.

- Demographic Data Collection: age, sex, CP subtype
- The GMFM-88 assessment was performed by trained physiotherapists in a standard environment following the protocol of GMFM-88.
- GMFCS Classification: Independently assessed by another physiotherapist blind to GMFM-88 scores
- Data Recording: GMFM-88 domain and total scores, GMFCS levels, and demographic data recorded in a structured spreadsheet.
- Reliability Procedures: Inter-rater reliability: 15% of participants assessed by two physiotherapists independently.

3.9 Statistical analysis tools

Analyses were performed with SPSS version 25.0, using a 0.05 level of significance for all statistical tests. All continuous variables were tested for normality using the Shapiro–Wilk descriptive test. Means and standard deviations are presented for each continuous variable. Differences in GMFCS groups were investigated using a one-way ANOVA with a Bonferroni post hoc test. A bivariate Spearman correlation analysis was performed to assess the relationship between motor capacity

GMFM-88 and GMFCS. Binary regression analyses were performed to predict GMFCS chosen as the dependent variable.

3.10 Ethical approval

Informed consent was obtained from parents or guardians of all participants. All procedures adhered to ethical standards for research with human participants. Every participant in the study received an explanation about the purpose, confidentiality of the study. Participation in the study was voluntary and all data and information gathered is strictly confidential and is not to be accessed by any other without prior permission from the participants, moreover, the participant had the right to withdrew at any time if he or she can't complete.

4. Results

This section outlines the study results about the attributes of the participants. It presents the demographic characteristics of the sample, followed by detailed findings on participants related to the study topic.

5.1 Socio-demographic characteristics of the Study Population

The most important information on the study population is given in Table 1. A total of (n = 50) data sets were available. The children had an average age of 7.54. years, the group had a higher percentage of boys (58.0%) compared to girls (42.0%). The majority of individuals with cerebral palsy (CP) exhibited the mixed type (34%), other classifications included dyskinetic (28%), spastic (24%), and ataxic (16%). The spread shows that the study sample included a lot of different kinds of CP subtypes. The GMFCS results showed that most of the children had mild to moderate movement impairments, with Level II (32%) and Level I (22%) being the most common classifications. Level III, IV, and V had 20%, 14%, and 12% of the subjects, which means that fewer children with major functional impairments were present.

Table 1: Demographic characteristics of the participants (N=50)

Characteristics		N	%	Mean (SD)
Age				7.54 (2.06)
Gender	Male	29		
	Female	21	42.0	
Type of CP	Spastic	12	24	
	Ataxic	8	16	
	Dyskinetic	14	28	
	Mixed	17	34	
Distribution GMFCS	I	11	22.0	
	II	16	32.0	
	III	10	20.0	
	IV	7	14.0	
	V	6	12.0	

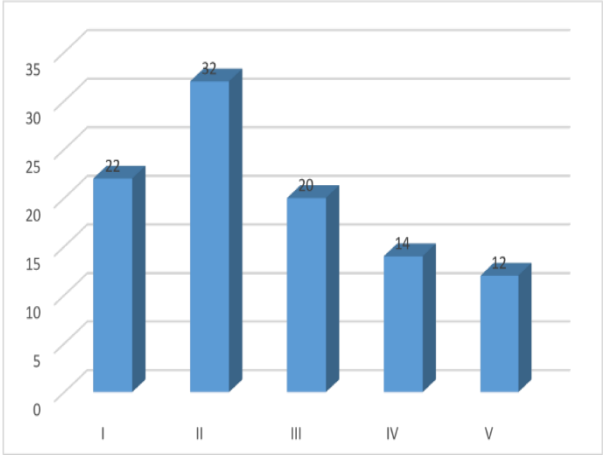

Figure 5: Type of CP

4.3 Descriptive Statistics of GMFM-88 Total and Domain Scores

The descriptive data for GMFM-88 domain and overall scores for all of the subjects are shown in Table 2. Dimension A (Lying & Rolling) had the highest mean scores, with a mean of 93.35 (SD = 15.11). This shows that most of the kids maintained a pretty good control of basic lying and rolling movements. Moreover, Dimension B (Sitting) has high mean scores (81.45 ± 24.44), which shows that many of the subjects were able to properly control their trunks while sitting. More complex motor tasks exhibited lower mean scores. The difficulty increased with higher dimensions: Dimension E (Walking, Running, & Jumping) recorded the lowest average at 45.14 (SD = 30.82); Dimension D (Standing) followed with an average of 54.79 (SD = 31.67); and Dimension C (Crawling & Kneeling) exhibited the greatest average at 66.06 (SD = 30.16). The mean total score of the GMFM-88 was 68.20 (SD = 24.80), with a range from 8.80 to 97.60. This advised variability in children's overall gross motor function. Which emphasized that the most of children maintained their fundamental motor abilities while they had difficulties when committed to complex movement activities.

Table 2: Descriptive Statistics of GMFM-88 Total and Domain Scores

GMFM-88 Measure	Min.	Max.	Mean	S.D
Dimension A: Lying & Rolling	37.30	100.00	93.35	15.11
Dimension B: Sitting	6.70	100.00	81.45	24.44
Dimension C: Crawling & Kneeling	0.00	100.00	66.06	30.16
Dimension D: Standing	0.00	100.00	54.79	31.67
Dimension E: Walking, Running & Jumping	0.00	91.70	45.14	30.82
GMFM-88 Total Score	8.80	97.60	68.20	24.80

4.4 Difference of GMFM-88 Total Scores Across GMFCS Levels

According to the finding in table 3, there were big differences in the average GMFM-88 total scores ($F = 216.2$, $p < 0.001$). Kids in GMFCS Level I got the best average score (90.89), in which showed that their gross motor function was nearly normal. Scores decreased as the GMFCS level increased: Level II (81.23), Level III (71.06), Level IV (42.23), and Level V (17.43). This indicates that increased gross motor weakness correlated

with elevated levels. This trend indicates that elevated GMFCS levels correlate with diminished gross motor function as assessed by GMFM-88.

Table 3: GMFM-88 Total and Domain Scores Across GMFCS Levels

GMFCS Level	*GMFM-88 Total (Mean)*	*SD*	*Test statistics*	*p- value*
I	*90.89*	*7.54*	*F=216.2*	*<0.001*
II	*81.23*	*5.93*		
III	*71.06*	*3.82*		
IV	*42.23*	*4.65*		
V	*17.43*	*5.16*		

4.4 Association Between GMFM-88 Scores and GMFCS Levels

Table 4. showed an established and statistically significant correlation between GMFM-88 scores and GMFCS levels in children with CP. A clear negative correlation existed between the GMFM-88 total score and GMFCS levels ($\rho = -0.909$, $p < 0.001$). This indicates that an increase in the GMFM-88 score correlates with a decrease in the GMFCS level. This indicates that children with higher GMFM-88 scores were more likely to be classified in lower GMFCS levels, indicating less severe impairment of motor function. On the contrary, children with diminished GMFM-88 scores were more often classified in elevated GMFCS levels, indicating greater motor impairment severity.All GMFM-88 domains showed negative correlations with GMFCS levels ($p < 0.001$), suggesting that superior performance in each motor domain was related to reduced functional intensity. The Walking, Running, and Jumping domain had the strongest correlation ($\rho = -0.912$), then by Standing ($\rho = -0.908$). The results illustrate that advanced motor abilities for standing and walking are specifically important in distinguishing between GMFCS levels.

The Crawling and Kneeling area revealed a high negative link ($\rho = -0.860$), which indicates that skills in this area, which include movement and different body positions, are very important for functional classification.

In the Sitting area, there was a high negative link ($\rho = -0.811$), which reveals the importance of this area to the overall muscle function.

However, the Lying and Rolling domain had a moderate negative link ($\rho = -0.536$). This means that basic motor skills are less important for distinguish the difference between GMFCS levels, especially in children who have less severe limits.

In General, these results show that GMFCS intensity goes down as GMFM-88 scores go up in all areas. The GMFM-88 is a useful tool for doctors who want to understand and compare how severely children with cerebral palsy are affected. This is because the greatest links were found in the areas of the GMFM-88 that looked at standing and walking.

Table 4: Association Between GMFM-88 Scores and GMFCS Levels

GMFM-88 Measure	**Spearman's ρ**	**p-value**
GMFM-88 Total	-.909**	<0.001
Lying & Rolling	-.536**	<0.001
Sitting	-.811**	<0.001
Crawling & Kneeling	-.860**	<0.001
Standing	-.908**	<0.001
Walking, Running & Jumping	-.912**	<0.001

4.6 Predicting GMFCS Levels.

The ability of the GMFM-88 total score, in conjunction with age and gender, to predict whether children were categorized as ambulatory (GMFCS I–III) or non-ambulatory (GMFCS IV–V) was investigated using binary logistic regression. None of the factors substantially predicted participation in the GMFCS group, according to the data (all p-values > 0.05). Higher GMFM-88 scores were linked to decreased likelihood of becoming non-ambulatory, according to the GMFM-88 total score's negative coefficient, however this association was not statistically significant. In a similar vein, neither gender nor age demonstrated any influence (Table 5)

Table 5 : Predicting GMFCS Levels (ambulatory I-III) and (non-ambulatory IV–V)
From GMFM-88 Total Score

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Total GMFM	-1.796	287.192	.000	1	.995	.166
	Age	-.937	1106.706	.000	1	.999	.392
	gender	5.889	18562.768	.000	1	1.000	360.942
	Constant	103.452	28201.101	.000	1	.997	8.481E+44

4.7 GMFM Cut-off Analysis for GMFCS Classification.

The GMFM cut-off value was determined using a centroid-based classification technique, where the mean GMFM scores of the two GMFCS categories were calculated, and the midpoint between these means functioned as the classification threshold. The average GMFM score for children categorized as GMFCS levels I–II was around 82, but the average score for those classified as levels III–IV was approximately 30.8. The average of these two means produced a cut-off value of 56.4, which was rounded to 60 for improved clinical interpretability. Those with a GMFM score of 60 or more were categorized as GMFCS levels I to II, while those with a score below 60 were categorized as GMFCS levels III to IV. This criterion was statistically determined to show a significant difference between the two groups.

4.8 Hypothesis Testing

The hypothesis testing findings in our study were summarized in the table below:

Table 6: hypothesis testing findings

Hypothesis	Statement	Key Findings	Decision
H1	GMFM-88 total score and domain scores significantly predict GMFCS levels (I–V) among children with cerebral palsy	Significant differences in GMFM-88 total scores among GMFCS levels ($F = 216.2$, $p < 0.001$). Strong negative correlations between GMFM-88 total and domain scores and GMFCS levels ($\rho = -0.536$ to -0.912, $p < 0.001$).	**Accepted**
H2	Higher GMFM-88 scores are associated with lower GMFCS severity (I–II), while lower scores are associated with higher severity (IV–V)	Mean GMFM-88 scores decreased progressively from GMFCS I to V. Strong negative association between GMFM-88 total score and GMFCS level ($\rho = -0.909$, $p < 0.001$). GMFM cut-off value (≈60) differentiated lower and higher severity levels.	**Accepted**
H3	There is no significant predictive relationship between GMFM-88 scores and GMFCS levels	Multiple analyses demonstrated statistically significant relationships between GMFM-88 scores and GMFCS levels ($p < 0.001$).	**Rejected**

5. Discussion

5.1 Background

This study aimed to investigate the gross motor functions in children with cerebral palsy and the relationship with functional classification using the GMFM-88 and GMFCS methods. The results demonstrated the obvious differences in gross motor functions among the children with different GMFCS levels and highlighted the importance of domain-specific examination.

5.2 Gross Motor Function Patterns

In addition, the descriptive analysis of the results of the GMFM-88 test revealed that the child's basic motor skills, such as Lying & Rolling (Dimension A) and Sitting (Dimension B), were relatively well preserved, as reflected by the mean scores of 93.35 and 81.45, respectively. On the other hand, the child's complex movement skills, including Standing (Dimension D) and Walking, Running & Jumping (Dimension E), scored lower (54.79 and 45.14), indicating greater difficulty, which is logical in the progression of children with CP. [19] and [18].

5.3 GMFM-88 Scores Across GMFCS Levels

Significant differences in the total score of the GMFM-88 were identified with respect to the children's GMFCS levels ($F = 216.2$, $p < 0.001$). The children in Level I had the highest total score in the GMFM-88 (90.89), followed by a sharp decline in the total score of children in Level V (17.43). These findings were in accordance with previous studies that identified the gross motor functions of children with CP to worsen with increasing levels of the GMFCS [15]; [16].

Domain-specific correlations were further substantiated to confirm that Standing ($\rho = -0.908$) and Walking, Running & Jumping ($\rho = -0.912$) were highly sensitive to functional severity, while Lying & Rolling was found to have a moderate correlation with functional levels ($\rho = -0.536$).

5.4 Correlation and Predictive Analysis

The strong negative correlation between the total score of the GMFM-88 and the levels of the GMFCS ($\rho = -0.909$, $p < 0.001$), which is in agreement with the correlation found in the study[15], , ($r = -0.91$), which promotes the reliability of the GMFM-88 in measuring gross motor functions. In Addition, logistic regression of the total score of the GMFM-88, age, and gender did not significantly predict ambulatory status (GMFCS I-III vs. IV-V). The negative coefficient of the total score of the GMFM-88 indicates that higher total scores of the GMFM-88 are related to lower likelihood of severe motor impairment.

5.5 Comparison with Previous Research

This study's findings are consistent with the findings of the past literature:

- Children who have lower levels of GMFCS have better gross motor function and reach a developmental plateau later than children who have severe impairments [17],[16].
- The study also found that the sections of the GMFM, namely D and E, are highly predictive of the level of the GMFCS [18], which is consistent with the finding that the standing and walking domains of the GMFM are important indicators of functional severity.
- The study addressed the issue of the relationship between motor capacities and activity in the real world [19], especially in children who have moderate impairments (GMFCS II-III).

5.6 Clinical Implications

The results also stress the need to use GMFM-88 and GMFCS together for clinical use. The interventions need to be specific to standing and walking skills, as they are more indicative of functional ability. The GMFCS has its own reference values, which can be used for goal setting and tracking. It is also important to recognize children with higher levels of GMFCS early on to allow them to reach their maximum developmental potential.

5.7 Limitations

This study has some limitations. Firstly, the study's design is based on collecting data at a single point in time. Therefore, the study cannot assess the changes in the development of motor skills. Thus, the development of motor skills cannot be concluded.

Secondly, the sample used in the study was small. The sample consisted of 50 children. The small sample used in the study could have affected the predictive regression analysis. Thus, increasing the sample used in the study could enhance the reliability and accuracy of the study.

Thirdly, the study was conducted in a few rehabilitation centers. Thus, the study's findings cannot be applied in all rehabilitation centers in Palestine. Variations in clinical practices in different centers can affect the study's findings.

6. Conclusion

This study aimed to examine the relationship between the scores of the Gross Motor Function Measure-88

(GMFM-88) and the levels of the Gross Motor Function Classification System (GMFCS) for children with cerebral palsy in Palestine. The results showed a significant relationship between the total and domain scores of the GMFM-88 and the levels of the GMFCS. This means that higher scores of the GMFM-88 correspond to lower levels of the GMFCS, which indicate better gross motor functions and mobility.

Children who obtained higher scores on the GMFM-88 tended to belong to lower levels of the GMFCS, which indicate lower motor impairments and greater independence in gross motor activities. Children who obtained lower scores on the GMFM-88 tended to belong to higher levels of the GMFCS, which indicate greater motor impairments and greater difficulties in performing functional activities. This inverse relationship supports the clinical relevance of the GMFM-88, which is a quantitative measure of motor performance.

Among the domains of the GMFM-88, the standing and walking/running/jumping domains had the strongest association with the level of functional severity of cerebral palsy. This further underlines the significance of these domains in the assessment of the level of gross motor impairments. Overall, the findings of the study recommended the use of the GMFM-88 as a means of obtaining a reliable measure of the level of functional severity of cerebral palsy in children.

The findings of the study also highlight the significance of the GMFM-88 in the sense that it offers objective numerical data to determine the level of a child's ability to perform gross motor activities, which is significant in the evaluation of the level of motor severity of cerebral palsy.

7. Recommendations

- Conduct researches focusing on larger sample sizes and avoid narrow geographic representation to generalize the results.
- Employ longitudinal study designs to examine motor development and changes in GMFM-88 and GMFCS scores over time.
- Utilize alternative and advanced statistical models to improve predictive accuracy.
- Investigate domain-specific cut-off scores for GMFM-88 to enhance the precision of GMFCS level classification.
- For better understanding the functional performance, it advised to explore combination of GMFM-88 with other assessment tools, such as the Manual Ability Classification System (MACS) and the Pediatric Evaluation of Disability Inventory (PEDI).
- GMFMA-88 as an assessment tool to classify the child using GMFCS.
- Using the GMFM-88 as part of the individualized rehabilitation planning to ensure maximum therapeutic outcome.

References

[1] S. Reffat and A. F. AL-Nemr, "Correlation between clinical measurement scales on gross motor function in children with spastic cerebral palsy," *Egypt Pediatric Association Gaz*, vol. 72, no. 1, p. 11, Mar. 2024, doi: 10.1186/s43054-024-00250-w.

[2]"mv2fIO4XVF1TbERz9cwytaKoWKAsRfslLobNuOmj7OPSAJOw2FvOCI_DQYaIXdf2i8gCmPHbCsav29dIHqW26gZu9qJDiW2QsifZt6FrdS4H2.pdf." Accessed: Feb. 11, 2026. [Online]. Available: https://site.moh.ps/Content/Books/mv2fIO4XVF1TbERz9cwytaKoWKAsRfslLobNuOmj7OPSAJOw2FvOCI_DQYaIXdf2i8gCmPHbCsav29dIHqW26gZu9qJDiW2QsifZt6FrdS4H2.pdf

[3] J. Ko, "Sensitivity to functional improvements of GMFM-88, GMFM-66, and PEDI mobility scores in young children with cerebral palsy," *Percept Mot Skills*, vol. 119, no. 1, pp. 305–319, Aug. 2014, doi: 10.2466/03.25.PMS.119c14z1.

[4] M. Salavati *et al.*, "Reliability of the modified Gross Motor Function Measure-88 (GMFM-88) for children with both Spastic Cerebral Palsy and Cerebral Visual Impairment: A preliminary study," *Res Dev Disabil*, vol. 45–46, pp. 32–48, 2015, doi: 10.1016/j.ridd.2015.07.013.

[5] M. Sadowska, B. Sarecka-Hujar, and I. Kopyta, "Cerebral Palsy: Current Opinions on Definition, Epidemiology, Risk Factors, Classification and Treatment Options," *Neuropsychiatr Dis Treat*, vol. 16, pp. 1505–1518, 2020, doi: 10.2147/NDT.S235165.

[6] S. Basoya, S. Kumar, and A. Wanjari, "Cerebral Palsy: A Narrative Review on Childhood Disorder," *Cureus*, vol. 15, no. 11, p. e49050, Nov. 2023, doi: 10.7759/cureus.49050.

[7] M. S, P. N, R. N. Karisaiyapannavar, and R. Halawar, "Spectrum of findings of magnetic resonance imaging of brain in cerebral palsy," *European Journal of Cardiovascular Medicine*, vol. 15, pp. 296–305, Jul. 2025, doi: 10.61336/ejcm/25-07-53.

[8] H. K. Graham *et al.*, "Cerebral palsy," *Nat Rev Dis Primers*, vol. 2, p. 15082, Jan. 2016, doi: 10.1038/nrdp.2015.82.

[9] R. E. Appleton and R. Gupta, "Cerebral palsy: not always what it seems," *Arch Dis Child*, vol. 104, no. 8, pp. 809–814, Aug. 2019, doi: 10.1136/archdischild-2018-315633.

[10] K. Yokochi, A. Hosoe, M. Kodama, and K. Kodama, "Assessment of upper and lower extremity movements in hemiplegic children," *Brain Dev*, vol. 14, no. 1, pp. 18–22, Jan. 1992, doi: 10.1016/s0387-7604(12)80274-9.

[11] H. Kerr Graham *et al.*, "Cerebral palsy," *Nat Rev Dis Primers*, vol. 2, p. 15082, Jan. 2016, doi: 10.1038/nrdp.2015.82.

[12] J. Ko and M. Kim, "Inter-rater Reliability of the K-GMFM-88 and the GMPM for Children with Cerebral Palsy," *Ann Rehabil Med*, vol. 36, no. 2, pp. 233–239, Apr. 2012, doi: 10.5535/arm.2012.36.2.233.

[13] J. Valentine *et al.*, "A prospective study investigating gross motor function of children with cerebral palsy and GMFCS level II after long-term

Botulinum toxin type A use," *BMC Pediatr*, vol. 20, no. 1, p. 7, Jan. 2020, doi: 10.1186/s12887-019-1906-8.
[14]MPT, MPH (NCD), Senior Clinical Physiotherapist, Physiotherapy Department, Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka, Bangladesh., Mst. R. Begum, M. A. Hossain, MPT, Associate Professor and Head of Physiotherapy Department, CRP, Savar, Dhaka, Bangladesh., S. Sultana, and MPT, Assistant Head of Program, CRP, Bangladesh., "GROSS MOTOR FUNCTION CLASSIFICATION SYSTEM (GMFCS) FOR CHILDREN WITH CEREBRAL PALSY," *IJPR*, vol. 7, no. 7, pp. 3281–3286, Dec. 2019, doi: 10.16965/ijpr.2019.180.
[15] R. J. Palisano *et al.*, "Validation of a model of gross motor function for children with cerebral palsy," *Phys Ther*, vol. 80, no. 10, pp. 974–985, Oct. 2000.
[16] P. L. Rosenbaum *et al.*, "Prognosis for gross motor function in cerebral palsy: creation of motor development curves," *JAMA*, vol. 288, no. 11, pp. 1357–1363, Sep. 2002, doi: 10.1001/jama.288.11.1357.
[17] I. Natroshvili, Z. Kakushadze, M. Gabunia, K. Davituliani, and S. Tatishvili, "Prognostic value of gross motor function measure to evaluate the severity of cerebral palsy," *Georgian Med News*, no. 126, pp. 45–48, Sep. 2005.
[18] D. J. Oeffinger *et al.*, "Gross Motor Function Classification System and outcome tools for assessing ambulatory cerebral palsy: a multicenter study," *Dev Med Child Neurol*, vol. 46, no. 5, pp. 311–319, May 2004, doi: 10.1017/s0012162204000519.
[19] M.-H. Suk, I.-K. Park, S. Yoo, and J.-Y. Kwon, "The association between motor capacity and motor performance in school-aged children with cerebral palsy: An observational study," *J Exerc Sci Fit*, vol. 19, no. 4, pp. 223–228, Oct. 2021, doi: 10.1016/j.jesf.2021.07.002.