Original Article

Association Between Gross Motor Function and Manual Ability in Children with Spastic Cerebral Palsy

Fahad Arif[1], Abdul Mannan[2]*, Javeria Jabeen[3], Humna Shahzad[4], Zonera Khalid[4], Nayab Qaiser[2]

[1]University of chester, UK
[2]Avicenna Medical College & Hospital, Lahore
[3]Dow University of health sciences, Karachi
[4]University of Balochistan, Quetta
Corresponding Author: Abdul Mannan; Email: abdulmannan9111@gmail.com
Conflict of Interest: None.

ABSTRACT

Background: Cerebral Palsy (CP) is a complex neurological condition that significantly impacts a child's motor abilities. Understanding the relationship between gross motor function and manual ability in children with CP, particularly spastic diplegia, is crucial for developing effective treatment strategies.

Objective: This study aimed to investigate the association between Gross Motor Function Classification System (GMFCS) levels and Manual Ability Classification System (MACS) as well as Bimanual Fine Motor Function (BFMF) in children with spastic diplegic CP.

Methods: A cross-sectional study was conducted involving 186 children aged 6-12 years with Diplegic CP, using convenience sampling. The GMFCS, MACS, and BFMF were employed to assess gross motor function, manual ability, and bimanual fine motor function, respectively. Data analysis was performed using SPSS 26.0, focusing on descriptive statistics and correlation coefficients.

Results: The mean age of participants was 8.35 years (SD = 1.998). The study comprised 57% male and 43% female participants. GMFCS levels distribution showed that the most common level was IV (31.2%), followed by levels III (19.4%) and V (18.8%). A strong correlation was observed between GMFCS and MACS ($r = .752$, $p < 0.001$) and a moderate to strong correlation between GMFCS and BFMF ($r = .618$, $p < 0.001$).

Conclusion: The study concluded that gross motor function significantly influences manual ability in children with spastic diplegic CP. Higher GMFCS levels were associated with more severe impairments in manual ability and bimanual fine motor function.

Keywords: Cerebral Palsy, Gross Motor Function, Manual Ability, Spastic Diplegia, Bimanual Fine Motor Function

INTRODUCTION

Cerebral palsy (CP) is a non-progressive neurological disorder caused by brain injury, affecting a child's ability to control movement and posture (1, 2). This disorder, which can occur before, during, or shortly after birth, is the most common motor disability in childhood, with an incidence of 1.5-4 per 1,000 live births (3). CP manifests in various forms, including spastic, dyskinetic, ataxic, and mixed types, each characterized by distinct motor impairments (4). Spastic CP, the most prevalent form, is marked by muscle spasticity and hypertonia. These motor dysfunctions significantly impact daily activities, particularly gross motor functions and manual abilities (5).

Gross motor functions, vital for tasks such as walking, running, and playing, involve large muscle groups (6). In children with spastic CP, these functions are often compromised due to disrupted muscle tone and coordination (7, 8). The Manual Ability Classification System (MACS) further classifies children based on their manual handling abilities in daily activities. The MACS has been found to have excellent reliability and validity, with intraclass association coefficients indicating strong agreement among analysts and between parents and analysts (9).

Recent studies have shed light on various aspects of CP. Odmen et al. (2010) found a strong correlation between age and self-care ability in children with CP, particularly those classified at lower MACS levels (10). Edvinsson et al. (2015) observed an increase in orofacial dysfunction with higher GMFCS and MACS levels (11). Yonsei Med J et al. (2018) reported that manual ability was more closely related to communication function in CP children than gross motor function (12). Soliemani Farin et al. (2011) noted that

bilateral spastic CP, the most frequent type, had the worst motor problems and challenging treatment (13). Gajewska et al. (2014) found an association between epilepsy in children with CP and the degree of mental impairment (14). Hangberg et al. (2018) emphasized the importance of classifying CP according to type and motor function, as these form an indicator of the total impairment load (15). Johnsen et al. (2006) highlighted the reliability of self-reported GMFCS levels compared to professional ratings, with changes in gross motor function often associated with physical or social environmental factors (16). Bakaniene et al. (2018) showed that TENS and physiotherapy groups in CP children improved in gross motor and mobility without significant differences (17). Roger et al. (2015) compared children with hemiplegia and diplegia within GMFCS levels, noting that those with hemiplegia performed better in lower extremity function but poorer in upper extremity and school function (18). Finally, Timen et al. examined how children with CP demonstrate differences in performance across various settings (19).

This body of research, while extensive, reveals a gap in the literature, particularly concerning the Pakistani context. The current study aims to address this gap, exploring the association between gross motor function and manual ability in children with spastic cerebral palsy within the unique social and cultural landscape of Pakistan.

MATERIAL AND METHODS

In the study, a cross-sectional design was employed to investigate the association between gross motor function and manual ability in children with Diplegic type of cerebral palsy. The research was conducted over a 12-month period following the approval of the synopsis, with data collection taking place at the Children's Hospital in Faisalabad.

The sample size for the study was calculated using Raosoft, resulting in a total of 186 participants. Convenience sampling was utilized to select the participants. The study focused on children aged 6 to 12 years who were diagnosed with Diplegic cerebral palsy and capable of following commands. The sample included children at any level of the Gross Motor Function Classification System (GMFCS). However, children with hand contractures, those who had undergone previous lengthening surgery of the hand, and those suffering from epilepsy were excluded from the study.

For data collection, several tools were employed. The GMFCS was used to classify the severity of cerebral palsy in participants. This system categorizes CP severity into five levels, ranging from level I, indicating no restrictions in walking but limitations in more advanced gross motor skills, to level V, where self-mobility is severely limited even with assistive technology. The inter-rater and intra-rater reliability for GMFCS were found to be 0.97 and 0.98, respectively. In addition to GMFCS, the Manual Ability Classification System (MACS) was used to evaluate hand capabilities. This system assesses a child's ability to use their hands. The MACS classifies hand function into five levels, with the inter-rater and intra-rater reliability being 0.95 and 0.96, respectively. Furthermore, the Bimanual Fine Motor Function (BFMF) was utilized to define various functional limitations using both palms. The reliability for BFMF was reported with inter-rater and intra-rater reliability scores of 0.85 and 0.90, respectively.

Before data collection commenced, consent forms, approved by the ethical committee of the university's institutional review board, were signed by all participants. Baseline measurements included descriptive data such as age, gender, family history, and other demographic data. These were collected from the child and their parents. Manual ability was assessed using the MACS and BFMF.

For data analysis, SPSS version 26.0 was employed. The analysis included descriptive statistics of demographic data, presented in the form of frequency tables and graphs. To determine the linear associations between Gross Motor Function Classification System, Manual Ability Classification System, and Bimanual Fine Motor Function, correlation coefficients were used, as all the data available was quantitative. This comprehensive approach ensured a thorough examination of the relationship between gross motor function and manual ability in children with Diplegic cerebral palsy.

RESULTS

Demographic Variable	Description	Statistics
Age of Participants	Mean and Standard Deviation	8.3548 (SD = 1.99808)
	Range	6 to 12 years
Gender	Male	106 (57.0%)
	Female	80 (43.0%)
Mode of Delivery	Normal	139 (74.7%)
	C-section	47 (25.3%)
Family History	Yes	28 (15.1%)
	No	158 (84.9%)
Total Participants		186

This table provides a detailed overview of the demographic characteristics of the participants in the study. The average age of the participants was 8.35 years, with a standard deviation of 1.998, covering a range from 6 to 12 years. Regarding gender distribution, the study included 106 males, constituting 57.0% of the participants, and 80 females, making up 43.0%. In terms of mode of delivery, a significant majority of the participants, 139 children (74.7%), were born through normal delivery, while 47 children (25.3%) were born via C-section. Concerning family history, only 28 participants (15.1%) had a family history of cerebral palsy, while the majority, 158 participants (84.9%), did not. The total number of participants in the study was 186.

Combined Table: GMFCS, MACS, and BFMF Classifications and Associations
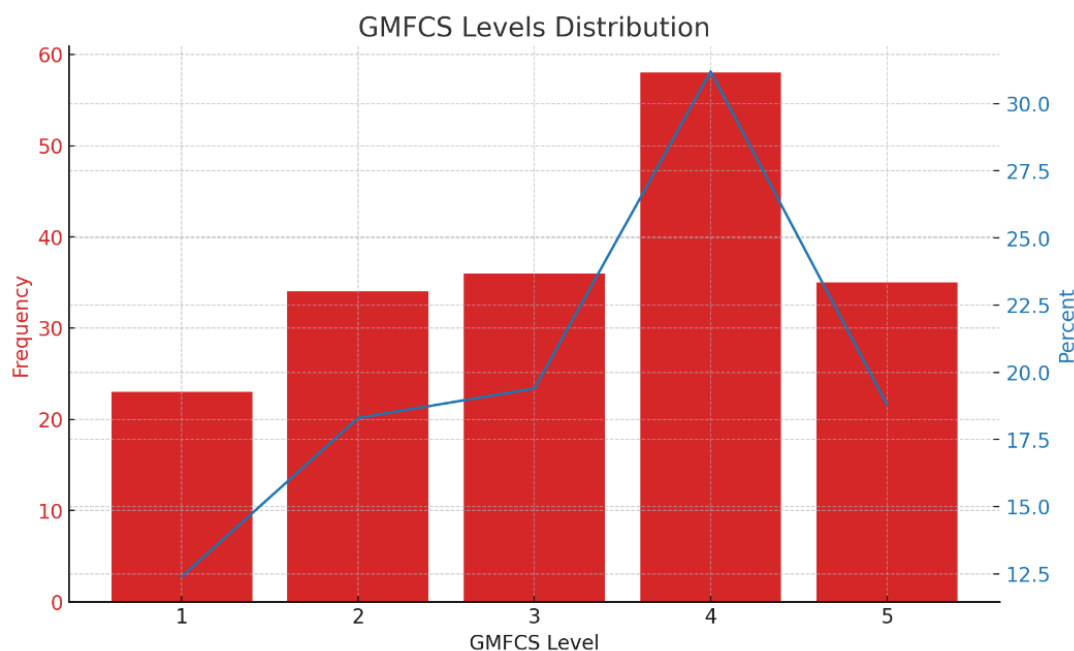
This figure illustrates the distribution of GMFCS (Gross Motor Function Classification System) levels among the participants. It shows that 23 participants (12.4%) were classified as GMFCS Level 1, 34 (18.3%) as Level 2, 36 (19.4%) as Level 3, 58 (31.2%) as Level 4, and 35 (18.8%) as Level 5. This distribution indicates a diverse range of motor function severity among the study's cerebral palsy participants.

Combined Table: Chi-Square Tests and Correlations

Test/Correlation	Pearson Chi-Square	Likelihood Ratio	Linear-by-Linear Association	N	Correlation Coefficient (r)	P value (2 tailed)
GMFCS & MACS	146.769	172.988	104.493	186	.752	<0.001
GMFCS & BFMF	94.920	110.276	70.624	186	.618	<0.001

This table presents the results of statistical tests and correlations between GMFCS & MACS (Manual Ability Classification System) and GMFCS & BFMF (Bimanual Fine Motor Function). The Pearson Chi-Square value for GMFCS & MACS was 146.769, with a Likelihood Ratio of 172.988 and a Linear-by-Linear Association of 104.493, indicating a significant association between these two classifications. The correlation coefficient (r) between GMFCS and MACS was .752 ($p < 0.001$), showing a strong positive correlation. Similarly, for GMFCS & BFMF, the Pearson Chi-Square value was 94.920, with a Likelihood Ratio of 110.276 and a Linear-by-Linear Association of 70.624, also indicating a significant relationship. The correlation coefficient between GMFCS and BFMF was .618 ($p < 0.001$), suggesting a moderate to strong positive correlation.

Descriptive Statistics for GMFCS, MACS, and BFMF

Variable	Mean	Std. Deviation
GMFCS	3.25	1.297
MACS	2.86	1.038
BFMF	2.90	1.130

This table provides mean and standard deviation values for the GMFCS, MACS, and BFMF scores of the participants. The mean GMFCS score was 3.25 with a standard deviation of 1.297, the mean MACS score was 2.86 (SD = 1.038), and the mean BFMF score was 2.90 (SD = 1.130). These statistics offer insight into the average motor function, manual ability, and bimanual fine motor function in the study's cerebral palsy population.

R^2 Linear = 0.382

$y = 1.15 + 0.54*x$
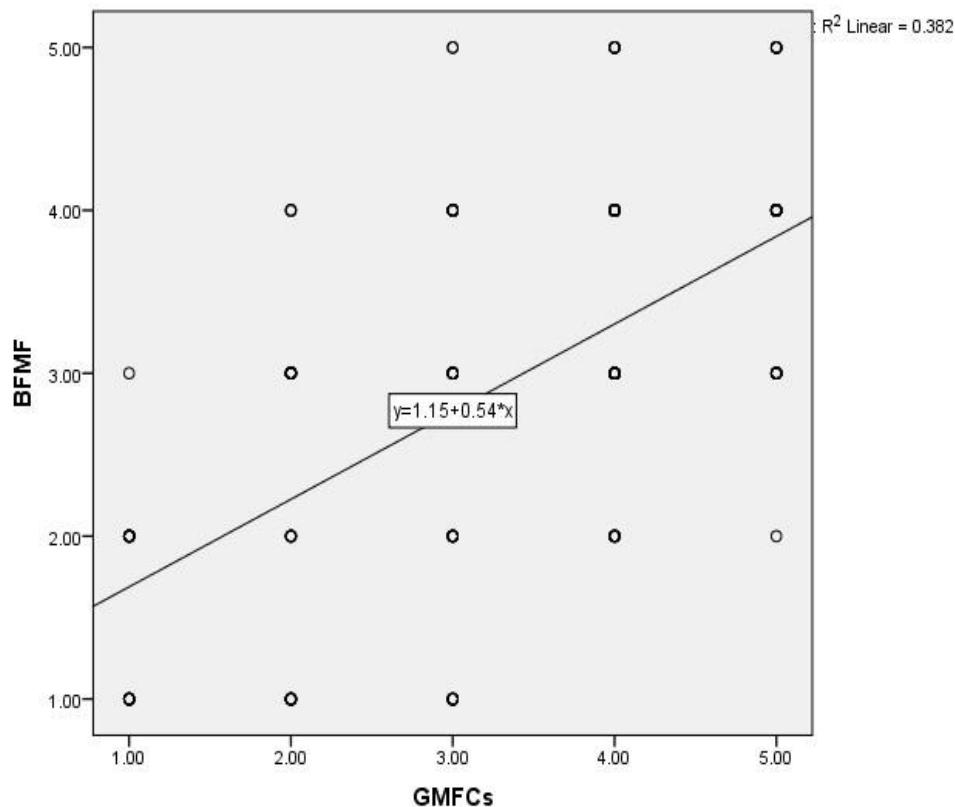
DISCUSSION

This study's findings align with those of several pivotal research studies in the field, underscoring the intricate relationship between gross motor function and manual ability in children with cerebral palsy (CP), particularly those with the spastic type (20, 21). Notably, the study corroborates previous findings indicating a significant correlation between the Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS), as well as the Bimanual Fine Motor Function (BFMF) (22).

Katharina Delhusen Carnahan et al.'s 2007 study highlighted a negative universal correlation between gross motor function and manual ability in the general CP population, observing specific associations in different diagnostic subtypes (22). Our findings particularly resonate with this study, especially in the context of children with spastic diplegia, where a strong association between GMFCS and MACS was noted.

Eliana Compagnon et al. in 2014 also found a variable correlation between general motor function and manual ability across different CP subtypes (21). They emphasized a strong association at the higher severity levels of these classifications, a finding that our study echoes.

Mintaze Kerem Gunel et al., in their 2008 study, observed a robust correlation between GMFCS and MACS in children with spastic CP, which aligns with our findings indicating a similar association in children with diplegic cerebral palsy (23).

Ann-Marie Ohrvall et al., in 2010, further explored the relationship between self-care, mobility skills, and functional classification systems in CP, finding that higher MACS and GMFCS levels correlated with lower performance in self-care and mobility (10). This study's outcomes are consistent with our findings, highlighting a significant association across all levels in children with diplegic CP.

Weinstein et al. in 2018 explored the broader relationships among vision problems, developmental stages, upper extremity functions, and life characteristics in children with CP (24). They found significant correlations between GMFCS, MACS, and BFMF scores, supporting our study's indication of a very strong association between GMFC and BFMF.

Drienne R.Harvey et al.'s 2013 study provided insights into functional profiles and movement disorder patterns in children with CP, observing milder limitations in various functions in children with CP born after 34 weeks of gestation (25). This study's results offer a broader context to our findings, suggesting a moderate association between GMFCS and MACS.

Himmelmann et al. in 2006 aimed to correlate activity limitations with GMFCS and a system for grading bimanual fine motor function (15). They observed a strong correlation between the GMFCS and BFMF, a finding that our study replicates, indicating a very strong association between these two classifications.

Lastly, Mintaze Kerem Günel et al. in 2007 and Roidi et al. in 2006 conducted studies that further reinforced the strong association between GMFCS and MACS, as well as GMFCS and BFMF in children with spastic CP (23, 26). These studies corroborate our findings, emphasizing the significant impact of gross motor function on manual ability and fine motor control in children with CP.

The study faced several limitations, including restricted resources and a narrow focus exclusively on spastic cerebral palsy. The short duration of the study and the limited scope in terms of age range also restricted the generalizability of the results.

Future research should explore the relationship between gross motor function and manual ability across different types of cerebral palsy. Additionally, the association of gross motor function with manual ability in the non-dominant hand warrants investigation. Furthermore, therapeutic interventions aiming to improve hand function should consider the level of gross motor function to tailor treatment more effectively.

CONCLUSION

The study concluded that there is a substantial impact of gross motor function on the manual abilities of children with cerebral palsy. Children with more severe gross motor dysfunction exhibited pronounced impairments in manual ability, whereas those with milder motor disabilities showed better manual skills.

REFERENCES

1. Patel DR, Neelakantan M, Pandher K, Merrick J. Cerebral palsy in children: a clinical overview. Translational pediatrics. 2020;9(Suppl 1):S125.

2. Schwabe AL. Comprehensive care in cerebral palsy. Physical Medicine and Rehabilitation Clinics. 2020;31(1):1-13.

3. Upadhyay J, Tiwari N, Ansari MN. Cerebral palsy: Aetiology, pathophysiology and therapeutic interventions. Clinical and Experimental Pharmacology and Physiology. 2020;47(12):1891-901.

4. Sadowska M, Sarecka-Hujar B, Kopyta I. Cerebral palsy: current opinions on definition, epidemiology, risk factors, classification and treatment options. Neuropsychiatric disease and treatment. 2020:1505-18.

5. Bader KA, Alghamdi SM, Aqueel HI. Effect of trunk control changes on access to children with progressive spastic cerebral palsy. Multi-Knowledge Electronic Comprehensive Journal For Education & Science Publications (MECSJ). 2022(60).

6. Bekteshi S, Monbaliu E, McIntyre S, Saloojee G, Hilberink SR, Tatishvili N, et al. Towards functional improvement of motor disorders associated with cerebral palsy. The Lancet Neurology. 2023.

7. Gharehbolagh SM, Dussault-Picard C, Arvisais D, Dixon P. Muscle co-contraction and co-activation in cerebral palsy during gait: A Scoping Review. Gait & Posture. 2023.

8. Thamm A. Improving gait in cerebral palsy: effects of a combined strength, flexibility and gait training Intervention on lower limb gait kinematics and kinetics in children and young adults with spastic cerebral palsy. 2021.

9. Ochandorena-Acha M, Terradas-Monllor M, Cabrera TFN, Rodas MT, Grau S. Protocol: Effectiveness of virtual reality on functional mobility during treadmill training in children with cerebral palsy: a single-blind, two-arm parallel group randomised clinical trial (VirtWalkCP Project). BMJ Open. 2022;12(11).

10. ÖHRVALL AM, ELIASSON AC, Löwing K, Ödman P, Krumlinde-Sundholm L. Self-care and mobility skills in children with cerebral palsy, related to their manual ability and gross motor function classifications. Developmental Medicine & Child Neurology. 2010;52(11):1048-55.

11. Edvinsson SE, Lundqvist LO. Prevalence of orofacial dysfunction in cerebral palsy and its association with gross motor function and manual ability. Developmental Medicine & Child Neurology. 2016;58(4):385-94.

12. Choi JY, Park J, Choi YS, Goh Y-r, Park ES. Functional communication profiles in children with cerebral palsy in relation to gross motor function and manual and intellectual ability. Yonsei medical journal. 2018;59(5):677-85.

13. Soleimani F, Vameghi R, Rassafiani M, AKBAR FN, Nobakht Z. Cerebral palsy: motor types, gross motor function and associated disorders. 2011.

14. Gajewska E, Sobieska M, Samborski W. Associations between manual abilities, gross motor function, epilepsy, and mental capacity in children with cerebral palsy. Iranian journal of child neurology. 2014;8(2):45.

15. Himmelmann K, Beckung E, Hagberg G, Uvebrant P. Gross and fine motor function and accompanying impairments in cerebral palsy. Developmental medicine and child neurology. 2006;48(6):417-23.

16. Jahnsen R, Aamodt G, Rosenbaum P. Gross Motor Function Classification System used in adults with cerebral palsy: agreement of self-reported versus professional rating. Developmental Medicine & Child Neurology. 2006;48(9):734-8.

17. Bakaniene I, Urbonaviciene G, Janaviciute K, Prasauskiene A. Effects of the Inerventions method on gross motor function in children with spastic cerebral palsy. neurologia i neurochirurgia polska. 2018;52(5):581-6.

18. Oeffinger D, Bagley A, Rogers S, Gorton G, Kryscio R, Abel M, et al. Outcome tools used for ambulatory children with cerebral palsy: responsiveness and minimum clinically important differences. Developmental Medicine & Child Neurology. 2008;50(12):918-25.

19. Tieman BL, Palisano RJ, Gracely EJ, Rosenbaum PL. Gross motor capability and performance of mobility in children with cerebral palsy: a comparison across home, school, and outdoors/community settings. Physical therapy. 2004;84(5):419-29.

20. 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;168:477-85.

Motor Function and Manual Ability in Spastic CP
Arif F., et al. (2023). 3(2): DOI: https://doi.org/10.61919/jhrr.v3i2.143

Journal of Health
and Rehabilitation
Research 2791-156X
JHRR

21.   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.

22.   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;8:1-7.

23.   Gunel M, Mutlu A. Disability and its relation with functional independence in children with cerebral palsy: an ICF study of preliminary clinical experience from Turkey. Fizyoterapi Rehabilitasyon. 2007;18(3):171.

24.   Weinstein M, Green D, Rudisch J, Zielinski IM, Benthem-Muñiz M, Jongsma ML, et al. Understanding the relationship between brain and upper limb function in children with unilateral motor impairments: a multimodal approach. european journal of paediatric neurology. 2018;22(1):143-54.

25.   Harvey AR, Randall M, Reid SM, Lee KJ, Imms C, Rodda J, et al. Children with cerebral palsy and periventricular white matter injury: does gestational age affect functional outcome? Research in developmental disabilities. 2013;34(9):2500-6.

26.   Roidi MLR, Isaias IU, Cozzi F, Grange F, Scotti FM, Gestra VF, et al. A new scale to evaluate motor function in Rett syndrome: validation and psychometric properties. Pediatric neurology. 2019;100:80-6.