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Association Between Motor Abilities And Cognitive Function In Children With Cerebral Palsy

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Abstract

Background

Cerebral palsy is a group of disorders that involve abnormalities in posture, disturbances in muscle tone, and limitations in activity. It is the most common physical disability of childhood and results from non-progressive damage to the developing fetal brain.

Objectives

The primary objective of this study was to investigate the association between cognition and motor function in children with cerebral palsy. The secondary objective was to evaluate the change in correlation between cognition and motor function over a period of six months in previously collected data.

Methodology

This cross-sectional study was conducted at the Helping Hand Institute of Rehabilitation Sciences, Mansehra. Participants who met the inclusion criteria were recruited through convenient sampling. Motor abilities were assessed using the Gross Motor Function Measure, and cognitive abilities were assessed using the Colored Progressive Matrices.

Results

A total of 106 children participated, of whom 63 percent were male and 37 percent were female. Most children were classified at level three for motor function and grade five for cognition. Simple linear regression analysis showed a positive moderate relationship between cognition and motor function ($R = 0.523$), with cognition variance explained at 27.3 percent and a significant p-value (≤ 0.001). Correlation analysis also demonstrated a positive moderate relationship ($r = 0.580$, $p \leq 0.001$). Wilcoxon testing revealed that the change in motor scores over six months ($\Delta = 15.2$) was not significant ($p = 0.096$), while the change in cognitive scores ($\Delta = 0$) was significant ($p = 0.023$).

Conclusion

The study found a positive moderate relationship between motor function and cognition in children with cerebral palsy. Significant variance was observed in motor and cognitive scores, and a positive moderate correlation was established. Over six months, cognitive scores showed a significant change, while motor scores did not.

Introduction

Cerebral palsy (CP) is the most common physical disability in childhood. It is defined as a group of permanent disorders of posture, movement, and muscle tone caused by non-progressive disturbances in the developing fetal or infant brain. Although CP itself does not worsen over time, affected children often develop secondary complications that further impair daily functioning and overall quality of life.(Patel et al., 2024)

The global prevalence of CP ranges from 1.5 to 3 per 1,000 live births, with significant variation across geographic regions and socioeconomic settings. In Asia, prevalence is relatively higher; for example, Bangladesh reports 3.4 cases per 1,000 children, equivalent to more than 230,000 affected individuals. (McIntyre et al., 2022)In Pakistan, data from Swabi district showed 1.22 per 1,000 live births.[4] By contrast, prevalence in high-income countries such as Europe, Australia, and the United States remains around 1.8–2.3 per 1,000 children.[5],[6] Studies from rural Africa, including Uganda, suggest even greater rates(Rafique, 2024)

Risk factors associated with CP include prematurity, low birth weight, and perinatal complications. However, epidemiological evidence shows that almost half of cases occur in children born at term without identifiable risk factors. Post-neonatal CP may arise from brain injury after birth, most often due to trauma, meningitis, or near-drowning before the age of five.[1] Spastic CP is the predominant clinical type, affecting up to 80 percent of cases, while ataxic and dyskinetic forms are less common.(Chen et al., 2022)

Children with CP present with a wide range of associated conditions, including epilepsy, musculoskeletal deformities, communication and behavioral difficulties, and cognitive and sensory impairments. (Bhatnagar et al., 2024) These comorbidities often have a stronger effect on daily life than the motor impairments themselves. As a result, children with CP usually require comprehensive medical, educational, and social support systems. Secondary complications such as hip displacement, equinus deformity, pain and balance problems further restrict independence.(Bekteshi et al., 2023)

Cognitive and learning difficulties are common in CP and have profound consequences on development and education. Problems with memory, attention, and executive functions reduce the ability to acquire academic skills and limit participation in daily life activities. These difficulties, combined with motor impairments such as weakness and poor coordination, make children highly dependent on caregivers for mobility and self-care, contributing to lower quality of life.(Wotherspoon, Whittingham, Sheffield, & Boyd, 2023)

Accurate assessment tools are critical for evaluating motor and cognitive abilities in children with CP. The Gross Motor Function Measure (GMFM) is regarded as the gold standard for motor assessment, providing reliable measurement across five functional domains: lying and rolling, sitting, crawling and kneeling, standing, and walking/running/jumping.[13] Cognitive assessment is equally essential for identifying intellectual difficulties and guiding educational planning. Traditional paper-based tests have long been used, but computerized methods now provide greater accuracy and more detailed analysis(Battisti et al., 2023)

Understanding both the motor and cognitive aspects of CP is essential for developing effective rehabilitation strategies. Addressing these domains together not only improves functional independence but also enhances the overall quality of life of children living with cerebral palsy.

Methods and Materials

This cross-sectional descriptive study was conducted at the Helping Hand Institute of Rehabilitation Sciences (HHIRS), Mansehra, over a period of four months. A non-probability convenient sampling technique was employed, and a sample size of 138 children with cerebral palsy was determined using G*Power, with correlation set at 0.3, alpha at 0.05, and power at 0.95. Children with a confirmed diagnosis of cerebral palsy who had received comprehensive rehabilitation, including physical therapy, occupational therapy, and psychological therapy, were eligible to participate. Both male and female children between the ages of 3.5 and 11.5 years were included. Children with malignancies, spina bifida, Down syndrome, systemic diseases, delayed milestones, autism, or other neurological disabilities were excluded. Ethical approval for the study was obtained from the Helping Hand Research and Ethical Committee (HHREC) under reference number (HHIRS/RD/2024/1183), and authorization was granted by CWDP management. Parents were informed about the study objectives and procedures, and written informed consent was obtained prior to participation to ensure voluntary enrollment and data confidentiality. Data were collected through direct assessment by experienced professionals. Each child's motor function was evaluated by a physical therapist using the Gross Motor Function Measure (GMFM), while cognitive abilities were assessed by an expert psychologist using Raven's Colored Progressive Matrices Test. Statistical analysis was performed using IBM SPSS version 22. Descriptive statistics summarized demographic data. Normality was assessed with the Kolmogorov-Smirnov test and box plots, indicating non-parametric distribution. Simple linear regression and scatter plots evaluated the association between gross motor function and cognitive function. Spearman's correlation examined cognition–motor relationships, while partial correlations assessed links with each gross motor dimension. Changes in motor and cognitive function after six months were analyzed using the Wilcoxon signed-rank test.

Results

In this study total n=106 patients was included with maximum age 11.5 and minimum 3.5 years the mean age was 6.731±2.704. Among 106 patients 95(89.6%) patients were spastic,1(0.94%) was choreo Athetoid, 2(1.88%) were ataxic while 8(7.5%) were athetoid. The distribution of participants across the Gross Motor Function Classification System (GMFCS) levels showed that the majority were in Level III (33%), followed by Level IV (28.3%) and Level V (21.7%). A smaller proportion of participants were classified as Level II (11.3%) and Level I (5.7%). This indicates that most of the study population had moderate to severe motor impairments. The Colored Progressive Matrices (CPM) grading revealed that the vast majority of participants were classified as Grade V (84%). A smaller proportion fell into Grade II (6.6%) and Grade IV (6.6%), while only 2.8% were in Grade III. No participants were categorized as Grade I. This distribution indicates that most of the sample demonstrated lower cognitive performance levels. Simple linear regression analysis showed a significant positive association between Gross Motor Function Measure (GMFM) and Colored Progressive Matrices (CPM) total scores. The model explained 27.3% of the variance ($R^2 = 0.273$) with a moderate correlation ($R = 0.523$). The regression coefficient ($\beta =$

0.164) indicated that higher motor function was associated with better cognitive performance. The model was statistically significant ($F = 39.137$, $p \leq 0.001$). The scatter plot illustrates the relationship between Gross Motor Function Measure (GMFM) total scores and Colored Progressive Matrices (CPM) total scores. A positive linear trend is observed, indicating that higher GMFM scores are associated with higher CPM scores. The regression line ($y = –2.16 + 0.16x$) represents this relationship, with the model explaining 27.3% of the variance ($R^2 = 0.273$). Although some variability is present, the overall trend demonstrates a moderate positive correlation between motor and cognitive function. Spearman's correlation analysis revealed a significant positive correlation between GMFM and CPM total scores ($r = 0.580$, $p \leq 0.001$, $n = 106$). This indicates that better gross motor function was moderately associated with higher cognitive performance. All GMFM dimensions showed significant positive correlations with CPM scores. Moderate correlations were found for lying & rolling ($r = 0.386$), sitting ($r = 0.447$), and crawling & kneeling ($r = 0.393$), while stronger correlations emerged for standing ($r = 0.574$) and walking, running & jumping ($r = 0.571$) (all $p \leq 0.001$).

Figure 1 (Gender of participants)

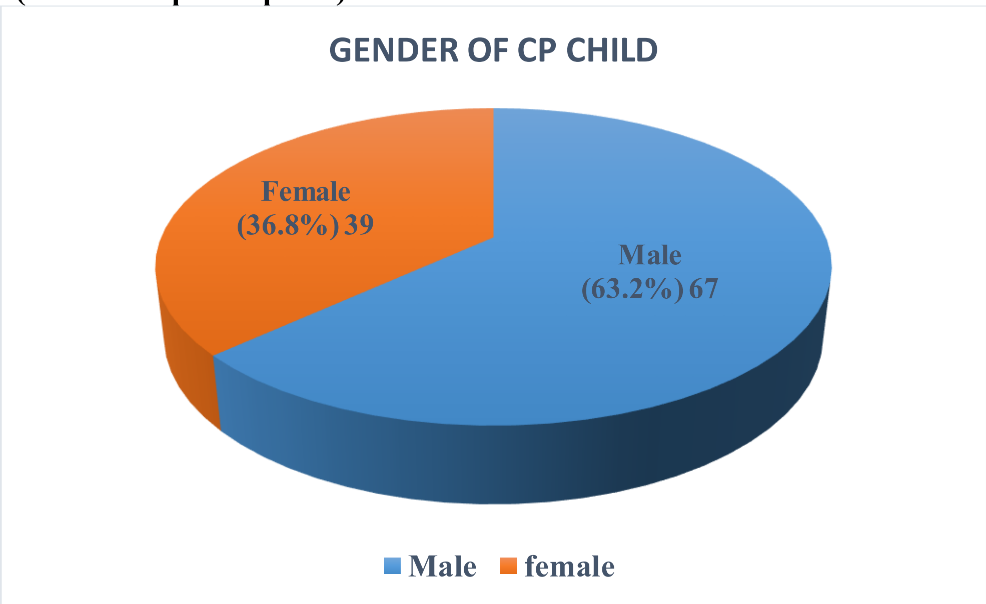


Figure 2 (Types of Cerebral palsy)

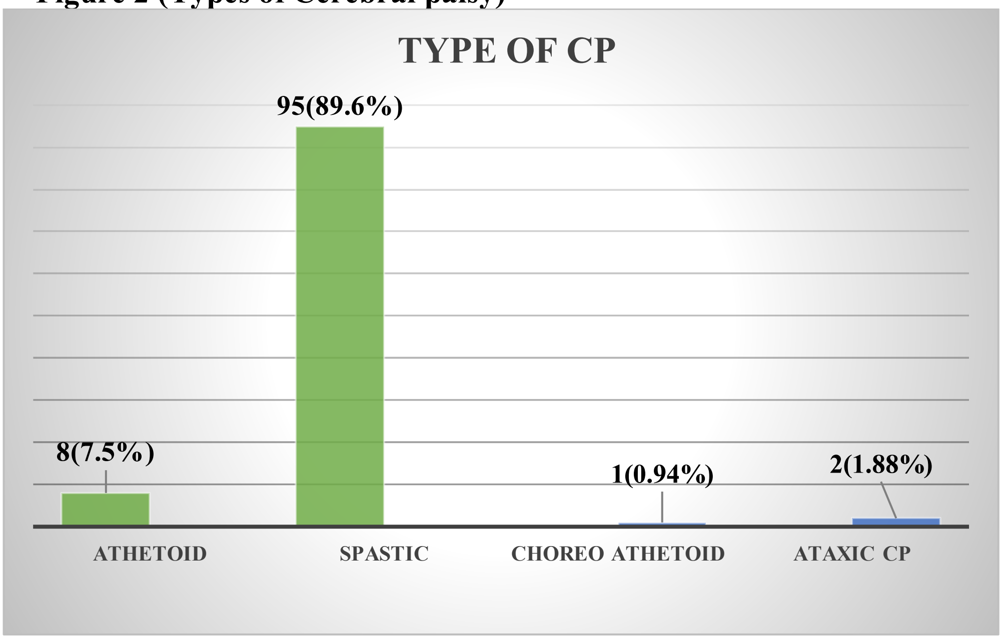


Table 1: Frequency and Percentage according to GMFM Level

GMFM LEVELS	
GMFCS LEVELS	FREQUENCY(PERCENT)
GMFCS Level I	6(5.7%)
GMFCS Level II	12(11.3%)
GMFCS Level III	35(33%)
GMFCS Level IV	30(28.3%)
GMFCS Level V	23(21.7%)

Table 2: Frequency and Percentage according to CPM Grade

COLORED PROGRESSSIVE MATRICS GRADE	
CPM Grade	FREQUENCY(PERCENT)
GRADE I	0(0%)
GRADE II	7(6.6%)
GRADE III	3(2.8%)
GRADE IV	7(6.6%)
GRADE V	89(84%)

Table 3: Simple Linear Regression between GMFM and CPM Total Score

SIMPLE LINEAR REGRESSION BETWEEN GMFM AND CPM TOTAL SCORE				
R	R^2	β Value	F Value	P value
.523	.273	.164	39.137	≤0.001

Figure 3 (Scatter Plot (Bivar) GMFM Total with CPM Total Score)

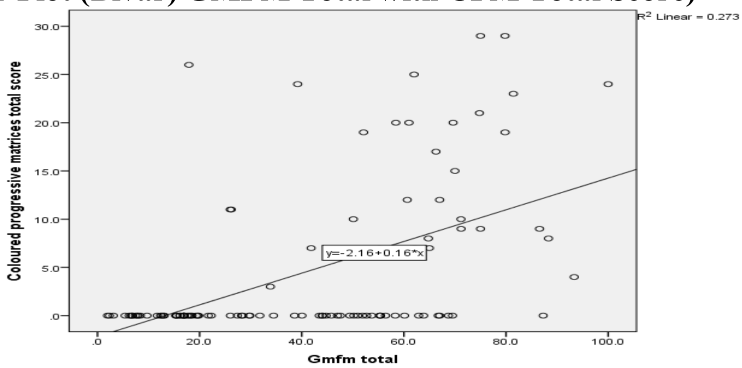


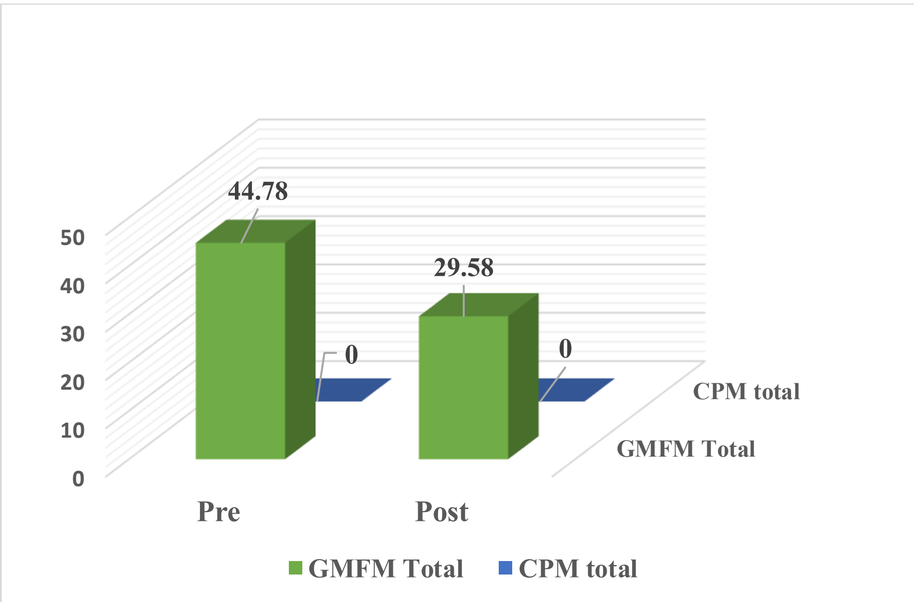
Table 4: Correlation Between GMFM Dimensions and CPM Total Score

CORRELATION BETWEEN GMFM DIMENSIONS & CPM TOTAL SCORE		
	r=	**Sig (2-tailed)**
Dimension A (Lying & Rolling)	.386	≤.001
Dimension B (Sitting)	.447	≤.001
Dimension C (crawling & kneeling)	.393	≤.001
Dimension D (Standing)	.574	≤.001
Dimension E (Walking, running & jumping)	.571	≤.001

Table 5: Pre and Post Analysis using Wilcoxen Signed Rank Test

		Med (IQR)	**Δ (%)**	**P =**
GMFM TOTAL SCORE	**Pre**	44.78(65.18-19.72)	15.2(33.94%)	0.096
	Post	29.58(61.4-14.98)		
CPM TOTAL SCORE	**Pre**	0(13.50-0.00)	0(0%)	0.023
	Post	0(4.75-0.00)		

Figure 4 (Graphical Presentation for Pre and Post Analysis)



Discussion

The study aimed to examine the association between cognition and motor abilities in children with cerebral palsy (CP) and to evaluate changes over six months. Simple linear regression revealed a moderate positive relationship between motor abilities and cognition ($R = .523$, $R^2 = .273$, $p \leq 0.001$). A significant moderate positive correlation was found between CPM and GMFM total scores ($r = .580$, $p \leq 0.001$). Correlations between cognition and GMFM dimensions were significant, with dimension A ($r = .386$) and C ($r = .393$) showing weak strength, while B ($r = .447$), D ($r = .579$), and E ($r = .571$) showed moderate strength ($p \leq 0.001$). The mean age of participants was 6.73 years (range 3.5–11.5), with 63% males. Most children were in GMFCS level III and CPM grade V. Wilcoxon signed-rank test showed significant change in CPM scores ($p = 0.023$), but not in GMFM scores ($p = 0.096$).

These findings are consistent with previous studies. Alaa Al-Nemr et al. (2018) reported strong positive correlations between GMFM dimensions D and E and selective attention, though not with figural memory, highlighting differences due to assessment tools and age groups.(Al-Nemr, 2024). Ballester-Plane et al. found that dyskinetic CP children had significantly lower cognition than typically developing peers, with cognition declining as motor severity increased.(Blasco et al., 2023). Dalvand et al similarly reported significant associations between motor and intellectual functions, with lower intelligence observed in GMFCS level V children.(Amiri, Dalvand, Rassafiani, & Almasi, 2023). Romeo et al also confirmed this correlation, though they noted better cognitive outcomes in females with hemiplegic CP under 4 years, with no difference in diplegia or quadriplegia.(Romeo, Venezia, Pede, & Brogna, 2023). Overall, the present study confirms a significant positive correlation between cognition and motor abilities in CP, particularly with stronger associations in standing, walking, running, and jumping functions.

However this study faced several limitations, including an incomplete predefined sample due to age restrictions in the inclusion criteria, limited resources, and lack of cooperation from some parents during data collection. The secondary objective could not be fully achieved, as 24 children were lost to follow-up and one participant died, leaving only 32 out of 57 cases for final analysis. Future studies should be designed with strategies to overcome these challenges and ensure completion of the targeted sample.

Conclusion

A linear positive moderate relationship found between motor function and cognition as well as variance in GMFM and cognitive scores was significant. The correlation between motor abilities and cognitive function was positive moderate significant. Moreover, the correlational change in baseline data was significant for pre-post cognitive scores and non-significant for pre-post motor scores.

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