

Risk factors affecting developmental functions in children with Cerebral Palsy: an analysis using GMFCS and PEDI scales

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HIGHLIGHTS

- Motor function and participation should be assessed with sociodemographic factors
- Maternal employment and paternal age influence outcomes in children with CP
- School attendance is associated with higher participation in children with CP

ABBREVIATIONS

ANOVA	Analysis of variance
CI	Confidence Interval
CP	Cerebral Palsy
GMFCS	Gross Motor Function Classification System
HSD	Honestly Significant Difference
IBM	International Business Machines
ICF	International Classification of Functioning, Disability and Health
PEDI	Pediatric Evaluation of Disability Inventory
PODCI	Pediatric Outcomes Data Collection Instrument
SPSS	Statistical Package for the Social Sciences
VIF	Variance Inflation Factor

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ABSTRACT

BACKGROUND: Cerebral palsy (CP) is a neurodevelopmental condition in which motor and functional outcomes are shaped by biological, familial, and environmental factors.

AIM: This study examined associations between child- and family-related characteristics and gross motor function, activity, and participation in children with CP.

METHODS: This cross-sectional study included 80 children with CP attending a Special Education and Rehabilitation Clinic. Maternal employment, paternal age, consanguinity, school attendance, and prematurity were recorded. Gross motor function was assessed using the Gross Motor Function Classification System (GMFCS), and activity and participation using the Pediatric Evaluation of Disability Inventory (PEDI). Independent t-tests and one-way ANOVA were used for group comparisons, and linear regression identified predictors of outcomes.

RESULTS: Higher paternal age was associated with better gross motor function ($p = 0.003$). School attendance was associated with higher PEDI self-care ($p = 0.002$) and social function ($p < 0.001$). Maternal employment was linked to lower GMFCS but higher social function ($p = 0.045$, $p = 0.022$). Consanguinity was associated only with social function ($p = 0.004$). Prematurity was associated with lower PEDI total and mobility scores ($p = 0.030$, $p = 0.041$).

INTERPRETATION: Familial and environmental factors showed differential associations with motor and participation outcomes in children with CP. School attendance was a consistent positive factor for participation, while prematurity was linked to poorer outcomes. Maternal employment and paternal age showed variable associations across domains, suggesting outcomes are shaped by multiple contextual determinants.

KEYWORDS: Cerebral palsy | Gross motor function | Activity participation | Family | Environmental factors

INTRODUCTION

Cerebral palsy (CP) is one of the most common non-progressive neurological disorders affecting an individual's activity level¹. The prevalence of this condition ranges from 1.5 to 4 cases per 1,000 live births within specific age groups². Children with CP experience numerous physical and social challenges, primarily due to impairments in the development of gross motor function. Consequently, improving gross motor function has become one of the primary focuses of rehabilitation programs for children with CP³. Gross motor function development is significantly associated with a variety of personal, familial, and environmental factors, which are linked to the acquisition of motor skills and participation in daily activities⁴.

Previous studies investigating factors affecting gross motor function in children with CP have primarily focused on motor impairments and demographic characteristics^{5,6}. However, a more comprehensive perspective that incorporates environmental and personal factors within the framework of the International Classification of Functioning, Disability and Health (ICF) is needed to better understand the multifaceted nature of gross motor function⁷. Social factors also play an important role in ensuring an effective rehabilitation process for children with CP⁸.

Studies examining the role of family in child development have generally focused on mothers. In contrast, fathers' contributions have been less extensively addressed⁹. However, fathers also play an important role in child development through caregiving and communication with their children¹⁰.

In this study, we aim to examine the role of familial and environmental factors in gross motor development and activity participation levels in children with CP. The study hypothesis was that familial and environmental factors would be associated with both gross motor function and activity participation levels in children with CP.

METHODS

Research Design

This study is an analytical cross-sectional investigation examining individual and environmental factors related to developmental functions in children with CP. Sociodemographic and clinical variables were assessed in relation to motor functions using descriptive and comparative statistical analyses.

Participants

The study included 80 children aged 5 to 18 years diagnosed with CP. Prior to participation, informed consent was obtained from the parents. For analytical purposes, participants were categorized into three age groups: 5–6 years, 7–11 years, and 12–18 years.

Sample size was calculated using G*Power 3.1 software based on a small effect size ($d = 0.35$), with reference to a study by Turhan et al. involving children with cerebral palsy. A total sample of 40 participants was initially estimated. Considering potential participant loss, this number was increased. A total of 87 participants were planned, based on a 95% confidence level and a 5% margin of error. During the assessment process, seven participants did not meet the inclusion criteria and were excluded from the study.

Consequently, statistical analyses were performed on 80 participants.

Inclusion criteria were: confirmed medical diagnosis of CP, age 5–18 years, having both biological parents alive and cohabiting with the child, ability to complete or tolerate GMFCS and PEDI assessments (directly or via caregiver report), clinical stability for functional assessment, and parental consent.

Exclusion criteria were: botulinum toxin injection, orthopedic surgery, or intensive rehabilitation within the last six months; acute or chronic conditions affecting motor performance (e.g., infection, respiratory disease); progressive neurological or degenerative disorders; severe cognitive or communication impairments; significant behavioral or psychosocial conditions interfering with participation or data collection; and parental separation or divorce due to the focus on intact family structure.

Sociodemographic Characteristics

Participants' age, sex, type of cerebral palsy, gestational age at birth, parental characteristics, and school attendance status were recorded using a sociodemographic data form.

The Gross Motor Function Classification System (GMFCS)

GMFCS is a five-level classification system used to assess gross motor function in children with CP, focusing on sitting, transfers, walking, and mobility¹¹. It classifies functional ability based on the need for assistive devices or caregiver support, with well-established validity and reliability. In this study, participants were grouped into four age categories (0–2, 2–4, 4–12, and 12–18 years) according to developmental stages to account for age-related differences in motor function¹².

Pediatric Evaluation of Disability Inventory (PEDI)

The Pediatric Evaluation of Disability Inventory (PEDI) assesses children's capability and performance in self-care, mobility, and social function. It consists of 197 functional skill items and can be administered through parent report or structured interview¹³. In this study, the original paper-and-pencil version of the PEDI was utilized.

The PEDI is a valid and reliable tool, showing higher internal consistency than other measures like the Pediatric Outcomes Data Collection Instrument (PODCI) and the Child Health Questionnaire in children with CP¹⁴.

Ethics Approval

The study was approved by the local ethics committee (Date: 22/07/2025 and No:2025-12/158) and was performed in accordance with the Declaration of Helsinki.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 22.0. Normality was checked with the Kolmogorov-Smirnov. Independent t-tests compared two groups, while one-way ANOVA analyzed three groups (5–6, 7–11, and 12–18 years). When significant differences appeared, Tukey HSD post-hoc tests were performed. In addition, linear regression analysis was conducted to identify independent predictors of motor and participation outcomes. Results with p-values below 0.05 were considered statistically significant.

RESULTS

A total of 87 children diagnosed with CP were assessed for the study. The analyses were conducted using data from 80 children with CP (Figure 1).

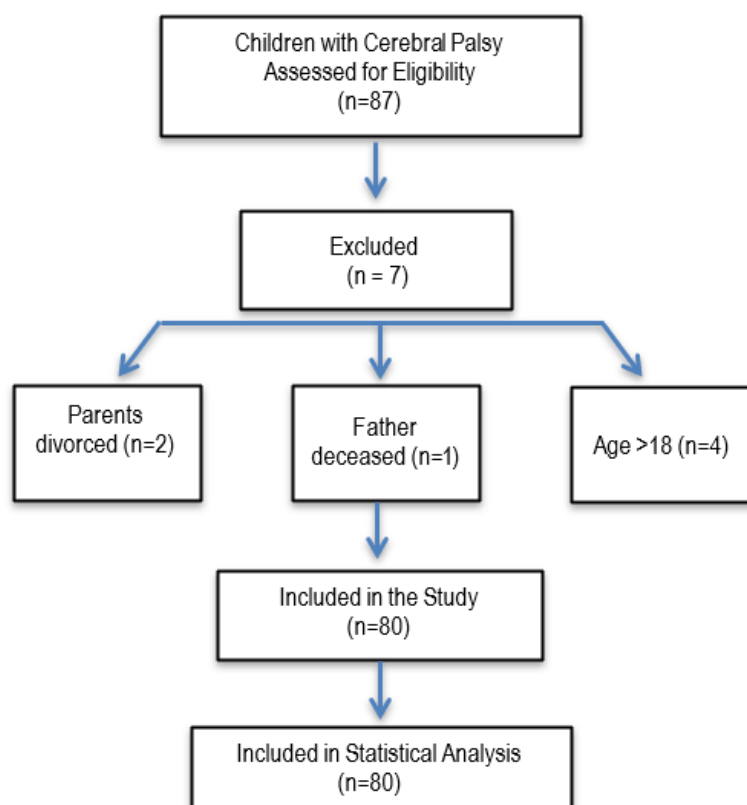


Figure 1. Flowchart of participant selection and inclusion in the study

A total of 80 children with CP participated in the study. Most were aged 12–18 years (57.5%), followed by 7–11 years (22.5%) and 5–6 years (20.0%). The majority had spastic CP (75%). The sample included 56.25% males and 43.75% females. Fathers were mainly aged 30–45 years (62.5%) (Table 1).

Table 1. Descriptive statistics of participants.

Variables	Category	Percentage (%)
Children's Age Groups	5–6 years	20
	7–11 years	22.5
	12–18 years	57.5
Cerebral Palsy Type	Spastic	75.0
	Dystonic	10.0
	Ataxic	8.75
	Dyskinetic	6.25
Gender	Male	56.25
	Female	43.75
Father's Age Groups	18–29 years	11.3
	30–45 years	62.5
	46–65 years	26.3

Children with CP whose mothers were employed demonstrated better gross motor function than those whose mothers were not employed ($p = 0.045$). However, the social skills of children with working mothers were significantly higher compared to those whose mothers didn't work ($p=0.022$) (Table 2).

Table 2. Comparison of GMFCS and PEDI scores by maternal employment status.

Variables	Mother's Employment Status	N	X	SD	t	df	p
GMFCS	Not Working	44	3.32	1.410	-2.052	52.142	0.045*
	Working	36	3.78	.422			
PEDI Total	Not Working	44	108.02	54.834	54.437	54.437	0.643
	Working	36	112.14	18.446			
PEDI Mobility	Not Working	44	31.25	19.509	1.321	48.108	0.193
	Working	36	27.25	4.325			
PEDI Social Function	Not Working	44	45.32	19.392	-2.333	77.678	0.022*
	Working	36	54.25	14.825			
PEDI Self-Care	Not Working	44	31.91	19.880	-0.383	55.018	0.703
	Working	36	33.14	6.867			

N = Number of participants; X = Mean value; SD = Standard deviation; t = T-statistic; df = Degrees of freedom; **p<0.05 ***

A significant association between parental consanguineous marriage and functional outcomes was observed only for Social function ($p = 0.004$) (Table 3).

Table 3. Comparison of GMFCS and PEDI scores by consanguineous marriage.

Variables	Consanguineous Marriage	N	X	SD	t	df	p
GMFCS	No	64	3.44	1.167	-1.890	37.402	0.066
	Yes	16	3.88	.719			
PEDI Total	No	64	108.75	45.708	-0.662	42.955	0.512
	Yes	16	114.38	25.179			
PEDI Mobility	No	64	29.73	15.974	0.470	41.332	0.641
	Yes	16	28.31	9.075			
PEDI Social Function	No	64	47.36	19.083	-2.998	51.218	0.004*
	Yes	16	57.25	9.118			
PEDI Self-Care	No	64	33.38	16.292	1.365	35.052	0.181
	Yes	16	28.81	10.597			

N = Number of participants; X = Mean value; SD = Standard deviation; t = T-statistic; df = Degrees of freedom; **p<0.05 ***

When examining the GMFCS and activity participation levels of children with CP based on birth term, it was found that full-term birth significantly increased PEDI ($p=0.030$) and Mobility ($p=0.041$) scores. Conversely, preterm birth was associated with a non-significant decrease in GMFCS ($p=0.066$), Social function ($p=0.078$), and Self-care ($p=0.182$) scores (Table 4).

Table 4. Comparison of GMFCS and PEDI scores by preterm birth.

Variables	Premature Birth	N	X	SD	t	df	p
GMFCS	No	30	3.23	1.194	-1.862	78	0.066
	Yes	50	3.70	1.015			
PEDI Total	No	30	123.03	43.148	2.206	78	0.030*
	Yes	50	101.98	40.212			
PEDI Mobility	No	30	33.80	15.522	2.077	78	0.041*
	Yes	50	26.84	13.882			
PEDI Social Function	No	30	53.63	14.871	1.788	72.958	0.078
	Yes	50	46.76	19.242			
PEDI Self-Care	No	30	35.60	17.196	1.423	78	0.182
	Yes	50	30.58	14.016			

N = Number of participants; X = Mean value; SD = Standard deviation; t = T-statistic; df = Degrees of freedom; **p<0.05 ***

When comparing GMFCS and PEDI scores according to school attendance status, significant differences were observed in PEDI total ($p < 0.001$), Social Function ($p < 0.001$), and Self-Care ($p = 0.002$) scores. Children with CP who attended school demonstrated better gross motor function and higher levels of participation in daily activities than those who did not attend school (Table 5).

Table 5. Comparison of GMFCS and PEDI scores by school attendance.

Variables	School Attendance	N	X	SD	t	df	p
GMFCS	No	48	3.52	1.185	-0.041	78	0.967
	Yes	32	3.53	0.983			
PEDI Total	No	48	97.56	45.089	-3.669	78.000	<0.001*
	Yes	32	128.34	29.941			
PEDI Mobility	No	48	27.83	15.566	-1.199	78	0.234
	Yes	32	31.88	13.483			
PEDI Social Function	No	48	42.00	18.506	-5.788	74.388	<0.001*
	Yes	32	60.34	9.647			
PEDI Self-Care	No	48	28.15	15.694	-3.257	78	0.002*
	Yes	32	38.94	12.523			

N = Number of participants; X = Mean value; SD = Standard deviation; t = T-statistic; df = Degrees of freedom; $p < 0.05$ *

Significant differences in GMFCS scores were found between fathers aged 18–29 years (Group 1) and 46–65 years (Group 3) ($p = 0.003$), with children of older fathers classified at lower GMFCS levels, indicating better gross motor function. PEDI scores also differed between Groups 1 and 3 ($p = 0.011$), with higher scores observed among children of older fathers. Mobility scores were significantly higher in Group 3 than in Group 2 ($p = 0.007$). For Social Function, a significant difference was found between Groups 1 and 2 ($p = 0.039$), with higher scores observed among children of younger fathers. Self-Care scores differed significantly between Group 3 and Groups 1 and 2 ($p = 0.004$), with higher scores observed among children of older fathers (Table 6).

Table 6. Comparison of GMFCS and PEDI scores by father's age.

Variables	SS	df	MS	F	p	Significance
GMFCS	13.299	2	6.649	6.195	0.003*	1-3
PEDI Total	15712.578	2	7856.289	4.808	0.011*	1-3
PEDI Mobility	2087.537	2	1043.769	5.270	0.007*	2-3
PEDI Social Function	1806.241	2	903.120	2.942	0.039*	1-2
PEDI Self-Care	2476.558	2	1238.279	5.887	0.004*	1-3, 2-3

SS= Sum of squares; df= Degrees of freedom; MS= Mean square; F= F-statistic; $p < 0.05$.*

Table 7 presents the results of the multiple linear regression analysis for GMFCS. Prior to the analysis, the assumptions of multiple linear regression were examined. Tolerance, VIF, and CI values indicated the absence of multicollinearity. The Durbin–Watson statistic showed no evidence of autocorrelation, while Cook's Distance values (maximum = 0.122) confirmed the absence of influential outliers.

Regression assumptions were met. The model was statistically significant ($F(8,71) = 63.410$, $p < 0.001$) and explained 86% of the variance in GMFCS scores (Adjusted $R^2 = 0.863$) (Table 7).

Table 7. Multiple Linear Regression Analysis Identifying Factors Associated with GMFCS Levels in Children with CP.

Variables	b	S.E.	95% CI (Lower-Upper)	β	t	p	Tol.	VIF	CI
Constant	5.021	0.415	4.193 to 5.848	–	12.101	<0.001*	–	–	–
PEDI Mobility	-0.061	0.005	-0.072 to -0.050	-0.814	-11.038	<0.001*	0.318	3.147	4.868
PEDI Social Function	0.027	0.004	0.019 to 0.036	0.448	6.298	<0.001*	0.342	2.920	7.247
PEDI Self-care	-0.030	0.006	-0.043 to -0.018	-0.425	-4.985	<0.001*	0.238	4.209	8.527
Age	-0.005	0.011	-0.028 to 0.018	-0.019	-0.440	0.661	0.882	1.133	9.380
Gender	0.043	0.102	-0.160 to 0.246	0.019	0.420	0.676	0.811	1.233	13.327
Maternal Employment	-0.061	0.142	-0.344 to 0.222	-0.028	-0.430	0.669	0.417	2.400	15.769
Father's Age	-0.067	0.119	-0.304 to 0.171	-0.036	-0.558	0.579	0.414	2.414	17.590
Child's School Attendance	0.108	0.116	-0.124 to 0.340	0.048	0.930	0.356	0.638	1.566	31.468

b= Unstandardized regression coefficient; S.E.= Standard error of the coefficient; 95% CI= 95% Confidence interval for the unstandardized coefficient; B= Standardized regression coefficient; t: T statistic; p < 0.05*; Tol.= Tolerance value; VIF=Variance inflation factor; CI= Condition index. F(8, 71) = 63,410 p<0.001; Adj. R² = 0.863; Durbin-Watson = 1.539.

DISCUSSION

This study examined individual and environmental factors related to gross motor function and activity participation levels in children with CP. The findings highlight the critical role of family structure and home environment in the child's developmental process¹⁵. Among family members, mothers play a central role in caregiving and spend more time with the child compared to others, with maternal interaction being particularly influential in shaping developmental trajectories^{16,17,18}.

Previous studies have suggested that maternal employment may be associated with differences in caregiving arrangements and child developmental outcomes^{19,20}. In the present study, lower gross motor function levels were also observed in children with CP whose mothers were employed. A possible explanation for this association is that maternal employment may be accompanied by changes in caregiving arrangements and in children's opportunities to participate in developmentally supportive activities²¹.

A study by Lobo and colleagues showed that having multiple caregivers is linked to better social skills in children²². In our study, maternal employment was linked to improved social skills in children with CP, consistent with existing literature. One possible explanation is that maternal employment may increase family economic resources, enabling greater participation in social activities and social engagement opportunities. Additionally, an employed mother may serve as a positive role model, which may contribute to social skill development²³.

A mother's employment may encourage the father to take a more active role in child care²⁴. The father's characteristics play an important role in meeting the child's needs and supporting their development. A study conducted in Japan reported that having an older father negatively affects child development²⁵. In our study, however, having an older father was found to be positively related to GMFCS and PEDI. The observed findings may be explained by the possibility that older fathers may provide a more stable and supportive environment for their children, which may facilitate engagement in activities that promote functional development²⁶.

Children born from consanguineous marriages have a significantly higher risk of various genetic disorders and physical illnesses compared to those born from non-consanguineous marriages²⁷. In the present study, children with CP born from consanguineous marriages demonstrated relatively higher social skill scores, a finding that appears counterintuitive. This result may be influenced by contextual and environmental factors that were not directly assessed in the present study. In sociocultural settings where consanguineous marriages are more common, extended family systems are often more cohesive and integrated, leading to increased interaction with multiple caregivers. This environment may provide greater social exposure, observational learning, and communication opportunities within a stable caregiving network, potentially supporting social development²⁸.

Besides family characteristics, child's environment also plays a crucial role in development. Among these environmental factors, school stands out as particularly important. Attending school is vital for the child's overall developmental progress²⁹. In our study, children with CP who attended school demonstrated higher PEDI scores, while no significant difference was observed in GMFCS levels according to school attendance. Higher PEDI scores may be explained by increased participation in school activities and routines, which can support a sense of belonging and contribute to socio-emotional skills such as self-regulation, self-awareness, and social awareness. These skills may facilitate greater independence and participation in daily activities³⁰. The lack of difference in

GMFCS levels may reflect the multifactorial nature of gross motor function in children with CP, which is influenced by various biological, clinical, and environmental factors beyond school participation³¹.

Based on the findings of this study, preterm birth was associated with lower scores across all assessed parameters in children with CP, with the strongest associations observed in the PEDI mobility domains. Existing literature indicates that preterm children are at increased risk for developmental challenges and motor coordination difficulties^{32,33}.

Furthermore, demographic characteristics did not significantly predict GMFCS levels, whereas all PEDI subdomains emerged as significant predictors, highlighting the close relationship between gross motor function and independence in daily living activities in children with CP.

Limitations and future directions

Several limitations should be considered. Key potential confounding variables, including family income, parental educational level, overall socioeconomic status, and family structure (nuclear versus extended family), were not assessed, which may partly explain the observed associations. Maternal employment was recorded in a dichotomous format (employed/unemployed), which does not capture important dimensions such as working hours, occupational demands, or job flexibility. Similarly, paternal involvement, including caregiving practices and emotional support, was not directly measured. Although chronological age was statistically controlled, the wide age range (5–18 years) may still introduce developmental heterogeneity that could influence functional outcomes. In addition, the distribution of cerebral palsy subtypes (unilateral versus bilateral) was not recorded, limiting more detailed subgroup analyses. Finally, the single-center design may restrict the generalizability of the findings across different sociocultural and healthcare settings.

CONCLUSION

This study examined relationships between selected familial and environmental factors and gross motor function and activity participation in children with CP. Maternal employment, paternal age, school attendance, prematurity, and consanguineous marriage were linked to differences in certain functional and participation outcomes. In particular, school attendance was linked to higher participation levels, while prematurity was linked to lower functional performance in some domains.

These findings underscore the importance of family and environmental contexts in evaluating functional outcomes in children with CP. Future longitudinal studies with larger, more diverse samples and comprehensive assessments of socioeconomic and caregiving factors, including parental involvement, are needed to clarify the underlying mechanisms and independent contributions of these factors to motor function and participation.

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