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Research Paper

Factors Related to Quality of Life in Children With Cerebral Palsy

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ABSTRACT

Background: We investigated the influence of relevant demographic, clinical, neuropsychological, and psychosocial variables on the proxy-reported quality of life (QOL) of children with cerebral palsy (CP).
Methods: The proxy-reported Cerebral Palsy Quality of Life-Child questionnaire (CP QOL-Child) was completed by 58 children with CP (mean age 10.22 years, SD 1.67). Relationships between QOL scores and demographic, clinical, neuropsychological, and psychosocial variables were assessed. CP QOL scores and other variables that correlated significantly were introduced into a multiple linear regression model.
Results: Executive functioning and motor functional status were explanatory variables for the CP QOL total score. Executive functions explained three specific QOL domains: Social Wellbeing and Acceptance, Feelings about Functioning, and Emotional Wellbeing and Self-esteem. Parental stress also explained Social Wellbeing and Acceptance. Motor functional status and visual perception were explanatory variables for the Access to Services domain. Finally, autism spectrum disorder (ASD) traits were an explanatory variable for the Participation and Physical Health domain.
Conclusion: Executive functioning and motor functional status importantly influence QOL of children with CP. Visual perception, ASD symptoms, and parental stress variables are related with specific QOL domains. These findings demonstrate that interventions targeting cognitive functions in children with CP may positively influence QOL.

Introduction

Cerebral palsy (CP) describes a group of permanent disorders of movement and/or posture attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain. Motor disorders are often accompanied by alterations in cognition, sensation, communication, perception, and behavior.[1] CP is a chronic condition that may have negative implications on quality of life (QOL) through life span.[2] The World Health Organization (WHO) defines QOL as "an individual's perception of their position in life in the context of the culture and values systems in which they live and in relation to their goals, expectations, standards and concerns".[3] The International Classification of Functioning, Disability and Health (ICF) model proposed by the WHO encourages the consideration of the impact of several biopsychosocial factors in daily life. The ICF framework suggests that QOL may be influenced by different domains that are interrelated: body function and structure, activities, participation, and contextual and personal

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factors.[4] Considering this framework, it is essential to identify the different factors that affect QOL in CP and that should be included in interventions. Motor functioning is one of the most studied factors influencing QOL in CP. Several studies have explored associations between QOL and gross[5-8] and manual[6,9,10] motor functions, type of CP, and motor distribution.[6,11] Research also indicates that clinical (epilepsy, pain, or communication)[6,8,9,11-13] and demographic (age, sex, and socioeconomic status)[5,9,11,12,14,15] variables influence QOL of people presenting CP.

Despite the importance of cognitive functions in CP, little is known about their impact on QOL. The few available studies exploring the association between cognitive functions and QOL have mainly focused on general intellectual functioning,[6-9,11] which is impaired in 50% of children with CP (intellectual quotient [IQ] < 70).[16-18]

Children with CP also present specific cognitive impairments. Concretely, visual perception and executive functions are the most affected cognitive domains in CP.[19-21] Nevertheless, research about the association between QOL and visual perception or executive functions is scarce.[9,22] Very few studies have described memory skills in people presenting with CP,[21,23-25] and two of them report difficulties.[21,25] Previous studies have demonstrated the importance of memory in children due to its role in learning and acquisition of knowledge in academic, leisure, and social contexts,[26] but association with QOL in CP has not been explored.

As for behavioral problems, associations have been explored between QOL and both prosocial behavior and psychopathology in children and adolescents with CP.[27,28] Autism spectrum disorder (ASD) traits in children with CP are higher than in typically developing children, with an estimated prevalence raised up to 30%.[18] No study to date has explored the association between ASD traits and QOL in children with CP. Considering these results, it is of special interest to conduct a study including all these neuropsychological variables to identify the best determinants on QOL.

Moreover, psychosocial variables such as type of schooling,[5,7] participation,[12,29] and parental stress[8] have been associated with QOL in children with CP.

Taking into account the biopsychosocial model proposed by the ICF, the aim of the present study was to investigate the influence of demographic, clinical, neuropsychological, and psychosocial variables on QOL of children with CP.

Materials and Methods

Participants

Participants were recruited from the Sant Joan de Déu-Barcelona Children's Hospital, Vall d'Hebron University Hospital, and Fundació ASPACE Catalunya in Barcelona. Ethical approval was obtained from the University of Barcelona's Institutional Ethics Committee, Institutional Review Board (IRB 00003099, assurance number: FWA00004225). The research was conducted in accordance with the Helsinki Declaration. Written informed consent was obtained by all parents or legal guardians of participants.

The inclusion criteria were (1) clinical diagnosis of CP; (2) children aged between 8 and 12 years; (3) being able to understand instructions assessed by the Screening Test of Spanish Grammar;[30] and (4) presence of an intelligible yes/no response system. The presence of severe hearing or visual difficulties that precluded neuropsychological assessment was considered as an exclusion criterion.

Assessments

QOL

QOL was measured using the parent-proxy version of the Cerebral Palsy Quality of Life-Child (CP QOL-Child) questionnaire. CP QOL-Child is a specific questionnaire designed for children with CP and based on the ICF. This questionnaire considers seven QOL domains: Social Wellbeing and Acceptance, Participation and Physical Health, Feelings about Functioning, Emotional Wellbeing and Self-Esteem, Pain and Impact of Disability, Access to Services, and Family Health. CP QOL-Child scores were converted to values between 0 and 100, and the mean for each domain was calculated. A CP QOL total score was also computed by adding all domains. Higher scores indicate better QOL except in Pain and Impact of Disability domain, where lower scores indicate better QOL.[31]

Demographic data

Participants' demographic data were obtained through parent's interview, including age, sex, and socioeconomic status.[32]

Clinical data

Clinical information, such as motor CP type, distribution of the motor impairment, motor functional status, communication, gestational age, presence of epilepsy,[33] and pain was extracted from clinical history and proxy-reported questionnaires.

Motor functional status. Gross motor function was assessed by the Gross Motor Function Classification System (GMFCS).[34] The GMFCS classifies children with CP based on their functional abilities and limitations. In addition, the Manual Abilities Classification System (MACS)[35] and the Bimanual Fine Motor Function (BFMF) system[36] were used to categorize manual ability. The three scales contain five levels of classification, and higher scores indicate lower levels of motor functioning.

Communication. Everyday communication abilities were assessed by the Communication Function Classification System (CFCS),[37] which contains five levels. Speech production was measured by the Viking Speech Scale (VSS),[38] which has four levels. Higher scores in both scales indicate higher difficulties.

Pain. Pain was assessed by the Bodily Pain and Discomfort Scale of The Child Health Questionnaire.[39] This questionnaire considers the presence of pain, frequency, and intensity during the last month. The frequency score was used in all analyses, and higher scores indicate higher frequency of pain.

Neuropsychological assessment

Participants completed a neuropsychological assessment to evaluate general intellectual functioning, visual perception, executive functions, and memory. Raw scores were converted into standardized scores to correct for age. Parents of participants completed questionnaires to assess psychological adjustment and ASD traits.

General intellectual functioning. General intellectual functioning was measured using the Raven's Coloured Progressive Matrices (RCPM).[40] RCPM is a standardized easy-to-administer tool in people with CP.[41,42] Higher scores in RCPM indicate better performance.

Visual perception. Visual perception was evaluated by the Facial Recognition Test (FRT)[43] and the Arrows subtest of the Developmental NEuroPSYchological Assessment-Second Edition (NEPSY-II).[44] Higher scores in both tests indicate a better performance.

Executive functions. According to Diamond's model,[45] both core (inhibitory control, working memory, and cognitive flexibility) and higher-order (planning) executive functions were assessed. Inhibitory control was assessed by the Digits total score from Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V)[46] and the Auditory Attention subtest of the NEPSY-II.[44] Working memory was assessed by using Backward Digit Span from WISC-V.[46] Cognitive flexibility was assessed by the Response Set subtest of the NEPSY-II,[44] and planning was assessed by using the Tower Test of the Delis-Kaplan Executive Function System (D-KEFS).[47] Social cognition was assessed using the Theory of Mind subtest of the NEPSY-II.[44] Higher scores in all these tests indicate a better performance.

To assess behavioral manifestations of executive functioning in everyday life, the parent-proxy version of the Behavior Rating Inventory of Executive Function-Second Edition (BRIEF-2) was used.[48] This scale comprises four indexes: Behavioral Regulation, Emotional Regulation, Cognitive Regulation, and Global Index of Executive Function. Higher T scores indicate worst performance.

Memory. Verbal and visual memory were measured using the Word Selective Reminding subtest of the Test of Memory and Learning (TOMAL)[49] and the Memory for Designs subtest of the NEPSY-II,[44] respectively. Higher scores indicate a better performance.

Psychological adjustment. The Strengths and Difficulties Questionnaire (SDQ)[50] completed by the parents was used to measure psychological adjustment including emotional, behavioral, and socialization problems. The total difficulties score, a measure of overall psychological adjustment, was used in all analyses. Higher scores indicate more presence of behavioral problems.

Autism spectrum disorder traits. The Autism Spectrum Screening Questionnaire (ASSQ) was used for the screening of ASD traits.[51] Higher scores on ASSQ indicate the presence of more ASD traits.

Psychosocial data

Psychosocial data included type of schooling, participation, and parental stress.

Type of schooling. Type of schooling was obtained through parents' interview, indicating mainstream school, mainstream with support class, mainstream school in special classroom, and special school.

Participation. Participation was evaluated by the Participation and Environment Measure for Children and Youth (PEM-CY)[52]; it examines the level of participation at home, school, and community settings, and higher scores indicate better participation.

Parental stress. Parental Stress Scale (PSS) was used to assess self-perceived stress from participants' parents.[53] Higher scores on the PSS scale indicate greater stress levels.

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS V.25). Assumptions of normality, linearity, and homoscedasticity were examined using the Kolmogorov-Smirnov test, scatterplots, and histograms. Pearson, Spearman, and Kendall bivariate correlations between the CP QOL scores and demographic, clinical, neuropsychological, and psychosocial variables were performed. Significance was set at $P < 0.05$ and corrected for multiple comparisons (Holm-Bonferroni). Those variables that correlated significantly after applying the Holm-Bonferroni correction were introduced into multiple linear regression models (stepwise method) to identify the best explanatory models of CP QOL scores. The assumption conditions of multiple linear regression model were checked. One participant was identified as an outlier in several scores of the neuropsychological assessment and was removed from correlation and regression analyses. The r and R^2 values were interpreted as measures of effects size, for correlation and regression models, respectively. Cohen's interpretative criteria[54] were applied considering r/R^2 effects as small $r \geq 0.10/R^2 \geq 0.01$, medium $r \geq 0.30/R^2 \geq 0.09$, and large $r \geq 0.50/R^2 \geq 0.25$. The significance level was set at P value <0.05.

Results

The present study includes 58 participants with CP with age ranging from 8 to 12 (mean age 10.22 years, SD = 1.67). Half of the sample was female, and most of the participants were diagnosed with spastic CP (91.4%). Only 29.3% of participants had epilepsy, and most participants reported experiencing pain (82.0%). Demographic and clinical information of the sample are summarized in Tables 1 and 2, respectively. The descriptive statistics for neuropsychological and psychosocial variables are presented in Tables 3 and 4. The mean CP QOL total score was 72.37 (SD = 9.94), and the highest scores were observed in the Emotional Wellbeing and Self-Esteem ($\bar{x}$ = 81.11, SD = 14.58) domains (Table 5).

Correlation analysis

Significant correlation coefficients between the demographic, clinical, neuropsychological, and psychosocial variables and the CP QOL scores after Holm-Bonferroni correction are presented in Table 6.

CP QOL total score

Gross motor function, executive functions in daily life, psychological adjustment, and ASD symptomatology scores were significantly and negatively correlated with the CP QOL total score (large and medium effect size). Demographic and psychosocial variables were not statistically associated with the CP total score.

Specific CP QOL domains

Demographic variables did not correlate with any specific domain. Regarding clinical variables, gross motor function (GMFCS) correlated negatively (medium effect size) with the scores in the Access to Services domain of the CP QOL questionnaire. No statistically significant correlation was found between the manual ability (MACS and BFMF) and communication (CFCS and VSS) scores and scores in any specific CP QOL domain.

In relation with neuropsychological variables, visual perception scores correlated positively (medium effect size) with Access to Services. The executive functions in daily life scale (BRIEF-2) scores were associated with scores in different CP QOL domains. Specifically, scores in four BRIEF-2 indexes (including the Global Index) were negatively associated with Social Wellbeing and Acceptance domain (large and medium effect size). Similarly, three BRIEF-2 indexes were negatively associated (large and medium effect size) with Feelings about Functioning and Emotional Wellbeing and Self-Esteem scores. Executive function performance-based test scores did not correlate significantly with any QOL domain. No association

TABLE 1.
Descriptive Statistics for Demographic Data

Age, mean (SD)/range	10.22 (1.67)/8-12
Sex, n (%)	Female: 29 (50)
	Male: 29 (50)
Socioeconomic status	A1 (>€3,005): 6 (10.3)
(monthly income), n (%)	A2 (€2,452-€3,005): 23 (39.7)
	B (€2,146-€2,451): 7 (12.1)
	C (€1,603-€2,145): 9 (15.5)
	D (€1,313-€1,602): 9 (15.5)
	E1 (€745-€1,312): 4 (6.9)

was found between IQ and memory with any of the CP QOL domains.

Psychological adjustment, as assessed by the SDQ total difficulties score, correlated negatively (medium effect size) with Social Wellbeing and Acceptance and Emotional Wellbeing and Self-Esteem domains. ASD symptoms (ASSQ) correlated negatively (medium effect size) with scores in the Participation and Physical Health domain.

Among psychosocial variables, parental stress (PSS) scores were significantly negatively associated with scores in the Social Wellbeing and Acceptance domain.

TABLE 2.
Descriptive Statistics for Clinical Data

Type of CP, n (%)	Spastic: 53 (91.4)
	Dyskinetic: 4 (6.9)
	Unknown: 1 (1.7)
Distribution of motor impairment, n (%)	Diplegia: 11 (19)
	Hemiplegia: 36 (62.1)
	Triplegia: 2 (3.4)
	Tetraplegia: 9 (15.5)
Motor functional status	
GMFCS, n (%)	I: 34 (58.6)
	II: 16 (27.6)
	III: 6 (10.3)
	IV: 2 (3.5)
MACS, n (%)	I: 24 (41.4)
	II: 28 (48.3)
	III: 6 (10.3)
BFMF, n (%)	I: 31 (53.5)
	II: 20 (34.4)
	III: 6 (10.3)
	IV: 1 (1.8)
Communication	
CFCS, n (%)	I: 35 (60.3)
	II: 18 (31)
	III: 3 (5.2)
	IV: 2 (3.5)
VSS, n (%)	I: 43 (74.1)
	II: 11 (19)
	III: 4 (6.9)
Gestational age (in weeks), n (%)	<37 w: 36 (62.1)
	≥37 w: 17 (29.3)
	Unknown: 5 (8.6)
Epilepsy, n (%)	No epilepsy: 41 (70.7)
	Active: 17 (29.3)
Pain, n (%)	Never: 24 (41.4)
	Once or twice: 14 (24.2)
	A few times: 8 (13.8)
	Fairly often: 5 (8.6)
	Very often: 1 (1.7)
	Every day or almost every day: 1 (1.7)
	Unknown: 5 (8.6)

Abbreviations:
BFMF = Bimanual Fine Motor Function
CFCS = Communication Function Classification System
CP = Cerebral palsy
GMFCS = Gross Motor Function Classification System
MACS = Manual Ability Classification System
VSS = Viking Speech Scale

Any of the demographic, clinical, neuropsychological, and psychosocial variables considered in the present study were not significantly correlated with Pain and Impact of Disability, and Family Health domains.

Regression analysis

The multiple linear regression models are presented in Table 7.

CP QOL total score

Clinical and neuropsychology variables were significant explanatory variables for CP QOL total score model. The multiple linear regression model for CP QOL total score indicated that motor functional status (GMFCS) and executive function in daily life (Global Index of Executive Function, BRIEF-2) were more impaired, CP QOL total score decreased.

Specific CP QOL domains

Clinical, neuropsychological, and psychosocial variables were significant explanatory variables for CP QOL domains in multiple linear regression models. According to effect size (from larger to smaller) for each multiple linear regression model, behavioral manifestations of executive functioning in everyday life (Global Index of Executive Function, BRIEF-2) together with parental stress (PSS) were related to Social Wellbeing and Acceptance domain (large effect size). Gross motor function (GMFCS) and visual perception (FRT) explained the variance in Access to Services domain (large effect size). Executive functions in daily life were also the only explanatory variables of two QOL domains: Feelings about Functioning and Emotional Wellbeing and Self-Esteem (large effect size). Finally, ASD symptomatology (ASSQ) alone was an explanatory variable (large effect size) for Participation and Physical Health domain model.

Discussion

This is the first study to investigate the association between QOL and a broad range of relevant variables including demographic, clinical, neuropsychological, and psychosocial variables in children with CP. Moreover, this research considers some variables that have not been studied previously in CP (such as VSS, memory, and ASD traits). Our results highlight that executive functions and motor functional status are key factors affecting QOL of children with CP. Visual perception, ASD traits and parental stress variables are related with specific QOL domains.

Taken together, a range of executive function components are associated with both QOL total score and with specific QOL domains. The BRIEF-2 Global Index seems to be a good predictor for the CP QOL total score and for the scoring in the Social Wellbeing and Acceptance domain in multiple linear regression models. The BRIEF-2 Cognitive Regulation Index was related with the Feelings about Functioning domain scores. In other words, this association indicates that problem-solving skills, as measured by Cognitive Regulation Index, play a role in individuals' feelings about their independence in daily activities. In addition, better emotion regulation skills, assessed by BRIEF-2 Emotional Regulation Index, were related with feeling good about oneself, as is described Emotional Wellbeing and Self-Esteem QOL domain. The importance of executive functions in QOL in people with CP through life span is ratified by our results and previous studies.[9]

Performance-based tests used in the present study to assess executive functions did not show any significant correlation with any QOL domain; this may due to the fact that performance-based tests have lower ecological validity than rating scales, as they assess aspects of executive functions that are required in everyday home and/or school settings.[55]

TABLE 3.
Descriptive Statistics for Neuropsychological Assessment

Neuropsychological variables	N	Mean (SD)	Range
IQ			
RCPM *(IQ)*	58	97.67 (12.57)	75-125
Visual perception			
FRT *(z)*	58	0.49 (1.50)	−2.90 to 4.33
NEPSY-II, Arrows *(z)*	58	−1.13 (1.22)	−3.00 to 1.67
Executive functions			
Inhibition			
WISC-V, Digits total score *(z)*	57*	−1.19 (0.97)	−3.00 to 0.67
NEPSY-II, Auditory Attention *(z)*	58		
Working memory			
WISC-V, Digit Span Backwards *(z)*	57*	−0.90 (1.39)	−4.40 to 1.44
Cognitive flexibility			
NEPSY-II, Response Set *(z)*	58		
Planning			
D-KEFS, Tower Test *(z)*	57†	−0.77 (1.09)	−3.00 to 2.00
Social cognition			
NEPSY-II, Theory of Mind *(z)*	57‡	−1.03 (1.02)	−2.19 to 1.50
Executive functions in daily life			
BRIEF-2, Behavioral Regulation Index *(T)*	58	61.79 (11.70)	42-90
BRIEF-2, Emotional Regulation Index *(T)*		64.00 (11.49)	42-89
BRIEF-2, Cognitive Regulation Index *(T)*		64.09 (10.87)	36-86
BRIEF-2, Global Index of Executive Function *(T)*		65.64 (11.12)	44-90
Memory			
Verbal			
TOMAL, Word Selective Reminding *(z)*	56*	−0.04 (1.00)	−2.33 to 1.33
Visual			
NEPSY-II, Memory for Designs *(z)*	55‡	−1.47 (1.30)	−3.00 to 1.00
Psychological adjustment			
SDQ, total difficulties score	56§	13.77 (5.76)	2.-32
ASD traits			
ASSQ	52§	10.06 (9.42)	0-36

Abbreviations:
ASD = Autism spectrum disorder
ASSQ = Autism Spectrum Screening Questionnaire
BRIEF-2 = Behavior Rating Inventory of Executive Function-Second Edition
D-KEFS = Delis-Kaplan Executive Function System
FRT = Facial Recognition Test
IQ = Intelligence quotient
NEPSY-Second Edition = Developmental NEuroPSYchological Assessment-Second Edition
RCPM = Raven's Coloured Progressive Matrices
SDQ = Strengths and Difficulties Questionnaire
TOMAL = Test of Memory and Learning
WISC-V = Wechsler Intelligence Scale for Children-Fifth Edition
Reasons for missing data:
* Very slow communication system that preclude to use an appropriate response system for the test used.
† Severe motor impairment that made it difficult to complete the task.
‡ Being not able to complete the test due to fatigue.
§ Not answered by the parents.

Visual perception skills were the other neuropsychological variable with significant impact on specific domains of QOL, such as the Access to Services domain; this may be due to the fact that children with visual perceptual impairments require more adaptations, such as special equipment and additional community services. However, difficulties to access these assistive technology resources decrease their individual's functioning and independence, consequently affecting their well-being.

TABLE 4.
Descriptive Statistics for Psychosocial Data

Psychosocial variables	N	n (%)/Mean (SD)	Range
Type of schooling (n)			
Mainstream school	58	29 (50.0)	
Mainstream school with support class		21 (36.2)	
Mainstream school in special classroom		3 (5.2)	
Special school		5 (8.6)	
Participation (mean)			
PEM-CY, frequency home	54*	5.56 (0.83)	2.80-6.70
PEM-CY, frequency school		4.26 (1.13)	1.75-6.20
PEM-CY, frequency community		2.61 (1.00)	0.50-5.30
Parental stress (mean)			
PSS	55*	25.56 (7.68)	13-45

Abbreviations:
PEM-CY = Participation and Environment Measure for Children and Youth
PSS = Parental Stress Scale
Reasons for missing data:
* Not answered by the parents.

TABLE 5.
Descriptive Statistics for CP QOL Domains

CP QOL Domains	N	Mean (SD)	Range
CP QOL total score	58	72.37 (9.94)	35.25-92.11
Social Wellbeing and Acceptance	58	80.93 (11.74)	52.08-100
Feelings about Functioning	58	72.94 (12.75)	31.25-94.79
Participation and Physical Health	58	67.51 (15.50)	13.64-88.64
Emotional Wellbeing and Self-Esteem	58	81.11 (14.58)	8.33-100
Access to Services	58	67.06 (18.35)	18.75-100
Pain and Impact of Disability	58	65.57 (13.86)	21.88-89.06
Family Health	58	70.76 (14.76)	37.50-100

Abbreviation:
CP QOL = Cerebral Palsy Quality of Life Questionnaire

TABLE 6.
Significant Bivariate Correlations Between CP QOL Domains Score and Explanatory Variables After Holm-Bonferroni Correction

CP QOL domains	$r_p/r_s/r^T$	*P*
CP QOL totalscore		
Motor status		
Gross motor function: GMFCS	-0.40^T	<0.001
Executive functions in daily life		
BRIEF-2, Emotional Regulation Index	-0.44_s	0.001
BRIEF-2, Cognitive Regulation Index	-0.42_s	0.001
BRIEF-2, Global Index of Executive Function	-0.48_s	<0.001
Psychological adjustment		
SDQ, total difficulties score	-0.44_s	0.001
ASD traits: ASSQ	-0.53_s	<0.001
Social Wellbeing and Acceptance		
Executive functions in daily life		
BRIEF-2, Emotional Regulation Index	-0.54_p	<0.001
BRIEF-2, Cognitive Regulation Index	-0.42_p	0.001
BRIEF-2, Behavioral Regulation Index	-0.50_p	<0.001
BRIEF-2, Global Index of Executive Function	-0.55_p	<0.001
Psychological adjustment		
SDQ, total difficulties score	-0.49_p	<0.001
Parental stress: PSS	-0.45_p	0.001
Feelings about Functioning		
Executive functions in daily life		
BRIEF-2, Cognitive Regulation Index	-0.42_p	0.001
BRIEF-2, Behavioral Regulation Index	-0.44_p	0.001
BRIEF-2, Global Index of Executive Function	-0.50_p	<0.001
Participation and Physical Health		
ASD traits: ASSQ	-0.46_s	0.001
Emotional Wellbeing and Self-Esteem		
Executive functions in daily life		
BRIEF-2, Emotional Regulation Index	-0.52_p	<0.001
BRIEF-2, Behavioral Regulation Index	-0.44_p	0.001
BRIEF-2, Global Index of Executive Function	-0.46_p	<0.001
Psychological adjustment		
SDQ, total difficulties score	-0.43_s	0.001
Access to Services		
Motor functional status		
Gross motor function: GMFCS	-0.38^T	<0.001
Visual perception: FRT	0.45_p	<0.001

Abbreviations:
ASD = Autism spectrum disorder
ASSQ = Autism Spectrum Screening Questionnaire
BRIEF-2 = Behavior Rating Inventory of Executive Function-Second Edition
CP QOL = Cerebral Palsy Quality of Life Questionnaire
FRT = Facial Recognition Test
GMFCS = Gross Motor Function Classification System
PSS = Parental Stress Scale
r_p = Pearson correlation
r_s = Spearman correlation
r^T = Tau Kendall correlation
SDQ = Strengths and Difficulties Questionnaire

TABLE 7.
Multiple Linear Regression Analysis Between CP QOL Domains and Potential Explanatory Variables That Correlated With CP QOL

CP QOL Domains	R^2	β	t
CP QOL total score			
Motor status: GMFCS	0.50	−0.50	−4.76***
Executive functions in daily life			
BRIEF-2, Global Index of Executive Function		−0.52	−4.94***
Social Wellbeing and Acceptance			
Executive functions in daily life			
BRIEF-2, Global Index of Executive Function	0.38	−0.45	−3.63***
Parental stress: PSS		−0.28	−2.31*
Feelings about Functioning			
Executive functions in daily life			
BRIEF-2, Cognitive Regulation Index	0.25	−0.50	−4.24***
Participation and Physical Health			
ASD traits: ASSQ	0.13	−0.36	−2.67**
Emotional Wellbeing and Self-Esteem			
Executive functions in daily life			
BRIEF-2, Emotional Regulation Index	0.25	−0.50	−4.07***
Access to Services			
Motor functional status			
Gross motor function: GMFCS	0.33	−0.38	−3.27**
Visual perception: FRT		0.33	2.86**

Abbreviations:
ASD = Autism spectrum disorder
ASSQ = Autism Spectrum Screening Questionnaire
BRIEF-2 = Behavior Rating Inventory of Executive Function-Second Edition
CP QOL = Cerebral Palsy Quality of Life Questionnaire
FRT = Facial Recognition Test
GMFCS = Gross Motor Function Classification System
PSS = Parental Stress Scale
* $P \leq 0.05$.
** $P \leq 0.01$.
*** $P \leq 0.001$.

Visual perception was not significantly associated with the CP QOL total score in our sample. To date, only one study has investigated the association between visual perceptual impairments and QOL.[22] Mitry et al.[22] found that visual perception was an explanatory variable of overall QOL in a sample similar to ours, with children aged between 6 and 11 years. The inconsistency between our findings and Mitry's et al.[22] could be due to the differences in motor severity between samples—our study did not include participants with severe motor impairment (GMFCS V). Accordingly, the rate of visual perceptual impairments was around 12% in our sample, whereas in Mitry et al.'s[22] sample 53% of participants presented these impairments. Another explanation for the different results between studies could be that the tool used to measure QOL was different between studies. Mitry et al.[22] assessed QOL through a generic questionnaire, whereas in the present study a questionnaire designed specifically to assess QOL in CP population was used.[31]

The lack of significant associations between QOL and general intellectual functioning in our study as an explanatory variable is consistent with Laporta-Hoyos et al.'s results.[9] However, other studies suggest that children with higher IQ tend to have better QOL.[6-8,11] The inconsistency between these findings and ours may be due to the tools used to measure IQ[8,11] or due to the fact that people with low IQ were also included in previous studies.[6,7] The mean IQ in our study was higher, and this might have influenced our results.

Memory skills were not associated with QOL in our sample. Pediatric studies exploring the association between memory and QOL are scarce. Only one study has found that verbal memory plays an important role in QOL in children with epilepsy,[56] which was not a common comorbidity in our sample.

The present study is the first one to explore the association between ASD symptoms and QOL in children with CP. Interestingly, only ASD symptoms explained the scoring in the Participation and Physical Health domain in the multiple linear regression model. This association is not surprising, as social communication difficulties can undermine participation in school, sporting, and community activities. Finally, it is important to highlight that ASD symptoms were significantly univariably correlated with the CP QOL total score, even though such association did not remain significant in the multiple linear regression model.

Psychological adjustment, as measured by the SDQ, was significantly and univariably associated with two QOL domains (Social Wellbeing and Acceptance and Emotional Wellbeing and Self-Esteem) and the CP QOL total score. Psychological adjustment, however, did not feature in any multiple linear regression model for QOL. These results agree with those of Power et al.[5] who found that SDQ scores were significantly univariably correlated with specific QOL domains.

Regarding motor functional status variables, aligning with previous findings,[5-8] GMFCS was associated with the total QOL in our study. Conversely, manual ability did not exert an impact on QOL. Consistently, Burak and Kavlav[29] did not find any association between manual ability and QOL in a sample including participants with similar MACS levels (I to III) to our sample. Previous studies including participants with greater levels of manual impairment, however, report significant associations between manual ability and QOL.[6,9,10] Similarly, other clinical variables (type of CP, distribution of motor impairment, communication, prematurity, and epilepsy) were not associated with QOL. Taken together, the results of the present and previous studies seem to indicate that these variables are associated with QOL when samples include children with severe communication difficulties, motor distribution impairment,[11] or more comorbidities.[15]

Concerning psychosocial variables, parental stress is associated with Social Wellbeing and Acceptance domain, which measures social network and personal relationships. These findings reinforce the idea that parental stress plays an important role in specific domains of QOL in children with CP.[5,8] In contrast to early findings,[5,7,12,29] type of schooling and participation were not associated with QOL in our study.

Finally, it is important to mention that two QOL domains (Pain and Impact of Disability, and Family Health) were not associated with any of the variables considered (demographic, clinical, neuropsychological, and psychosocial). Pain and Impact of Disability domain was perceived as the least satisfactory domain, as in previous findings.[6]

This is the first study exploring the association between QOL and a wide range of biopsychological variables considering the ICF framework for children with CP, but some limitations should be considered. First, sample size is moderate, and future studies including larger samples will provide further understanding about which factors influence QOL. Second, our sample included children with mild manual motor impairments (MACS I to III). Although there is a lack of participants with severe motor impairments to cover the whole spectrum, our results reinforce the effect of some variables in QOL in mild cases. Finally, we relied on parental reports to measure QOL. Previous studies indicate that the perception of QOL may differ between self-reports and proxy reports, as caregivers tend to underestimate the QOL of children and adolescents with CP.[28,57] However, the biopsychological approach of our study allows a comprehensive understanding of variables that may impact QOL.

In conclusion, our study identified that executive functions, motor functional status, visual perception functions, ASD symptoms, and parental stress were significant explanatory variables in multiple linear regression models for QOL. Importantly, executive functions were significant explanatory variables in several QOL domains, highlighting their key role in QOL. Given their influence in QOL, cognitive functions, especially executive and visual perception functions, together with ASD traits should be targets for intervention in children with CP.

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