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Research Paper

The Relationship Between the Functional Status of Children With Cerebral Palsy and Physiological and Topographical Classification

Azade Riyahi[1], Hosseinali Abdolrazaghi[2], Zahra Nobakht[3*]

1. Department of Occupational Therapy, School of Rehabilitation, Arak University of Medical Sciences, Arak, Iran.
2. Department of Hand and Reconstructive Surgery, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran.
3. Department of Occupational Therapy, Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

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ABSTRACT

Background and Objectives: Cerebral palsy (CP) refers to a group of permanent disorders of posture and movement caused by non-progressive disturbances to the developing fetal or infant brain. The dominant clinical sign is the impairment of gross motor functions. Additionally, more than half of these children experience limitations in their hand function. Gross motor function and manual ability limitation are differently disturbed in the physiological and topographical classification of CP. This study aimed to determine the functional status of children with CP and its relationship with the physiological and topographical classification of CP.

Methods: This cross-sectional study was conducted in 2023 and involved children with CP aged between 4 and 18 years. The participants were conveniently recruited from various clinics, rehabilitation centers, and exceptional schools in Tehran and Arak cities, Iran.

Results: A total of 305 CP children (174 males and 131 females) aged 4–18 years were evaluated in this study. The results indicated a significant relationship between the physiologic classification of CP and the level obtained from the manual abilities classification system (MACS) scale (P<0.01). According to the results, a significant correlation was observed between the levels of the gross motor function classification system and MACS in children (P<0.01). Children with spastic diplegia were predominantly distributed in levels I and II of the MACS. In contrast, children with spastic quadriplegia were mostly distributed in levels III, IV, and V of the MACS. Due to using the unaffected hand, hemiplegic children were mostly distributed in levels I and II of MACS.

Conclusion: These results highlight the significance of understanding the relationship between the physiological classification of CP and its associated functional abilities. The significant correlations observed in this study suggest that targeted interventions can be developed to enhance motor function and the overall quality of life for children with CP, particularly focusing on the specific needs associated with their classification levels.

Keywords: Cerebral palsy (CP) classification system, Physiological classification, Topographical distribution

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*** Corresponding Author:**
Zahra Nobakht, Assistant Professor.
Address: *Department of Occupational Therapy, Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.*
Tel: *+98 (71) 732850*
E-mail: *nobakht.zahra@gmail.com*

What is "already known" in this topic:

CP is a group of non-progressive motor disorders resulting from brain injury. Gross motor function and manual ability are common, validated tools used to classify functional limitations in CP. Previous studies have established that children with CP often experience varying degrees of limitations in gross motor functions and manual abilities.

What this article adds:

This study reinforces the link between physiological classification (CP type) and functional outcomes (MACS and gross motor function) in a sizable pediatric sample. It demonstrates that gross motor and manual abilities are correlated across CP subgroups, with distinct patterns by topography (e.g. diplegia vs. quadriplegia and/or hemiplegia). It suggests that classification-informed, targeted interventions may optimize motor function and the overall quality of life for children with CP. It provides evidence to support integrated assessment using both physiologic and functional scales to guide individualized care plans.

Introduction

Cerebral palsy (CP) is a group of permanent disorders that causes activity limitations and is attributed to non-progressive disturbances [1, 2]. CP occurs in about 2–2.5 per 1000 live births [3]. The average prevalence of CP in Iran is reported as 2 per 1000 live births [4]. The associated problems with CP include disturbances in cognition, sensations, perception, communication, behavior, seizures, secondary musculoskeletal disorders, and incontinence [5].

The classification of children with CP in the last two decades has been based on criteria such as central control and area involved in the brain, the nature and type of motor disorder, physiological distributions, and functional motor abilities. The physiological classification divides CP into spastic paralysis, dyskinesia, ataxia, hypotonic, and mixed. Spastic CP is the most common type and usually covers half of these children. Spastic muscles are stiff and strongly resist the stretch. These muscles are excessively activated, resulting in dry and harsh movements. Muscle spasticity generally changes over time. Dyskinetic paralysis involves disturbances in the control and coordination of movements, affecting approximately a quarter of these children. Torsional, involuntary, and repetitive movements are the characteristics of these children. Their uncontrollable movements generally increase during stressful times and disappear during sleep. Ataxia paralysis is the rarest type (about 10%). Disturbance in the sense of balance and perception of depth is one of its symptoms. The muscle tone of these children is low, and their muscles are flaccid. Their walk is staggering, and their upper extremities are unstable when walking. Muscle tone is abnormally reduced. It is the most commonly impaired muscle tone in early neonates with neurological abnormalities. In mixed paralysis, conditions previously described in the four types of CP occur in combination. About a quarter of children with CP are classified in this type [4]. Spastic CP is divided into 5 categories based on the topographic distribution: Quadriplegia (involvement of all four limbs), diplegia (usually the lower limb is more involved than the upper limb), hemiplegia (involvement of one side of the body; normally the upper limb is more involved than the lower limb), triplegia (involvement of three limbs, typically two hands and one leg), and monoplegia (only one limb is involved, usually one hand) [6, 7]. These classifications do not provide a clear picture of the child's performance and ability consistent with the International Classification of Functioning; all are based on disability. Therefore, the functional performance of upper and lower limbs should be classified by functional scales [8, 9].

A group of classification systems focusing on manual function includes the House classification, modified House classification, and Zancolli classification systems. The other group focuses on manual functional capacity (e.g. what a child can do). However, none of these classifications describes everyday routines. Therefore, there was a need for a simple and fluid instrument that focuses on the implementation of daily activities [6]. In recent years, functional categories have been used to describe the heterogeneous group of children with CP and to recognize the diagnosis of CP. Since 1997, two systems have been developed for classifying children with CP based on their functional ability: The GMFCS-E&R system and the manual abilities classification system (MACS) [8].

CP neurological symptoms can be detected through early imaging and clinical tests. Determining the type of CP can be challenging during the first year of life. Diagnosis should be confirmed when the child is about 4 years of age. However, it is important to describe the child's functional ability as soon as possible. The most important thing for the parents of children with CP is the symptoms of CP. The use of a functional classification system demonstrates a shift whereby researchers and physicians consider the results of CP in terms of its impact on the child's daily performance, rather than in terms of neurological states and milestones. After determining the range of performance limits for resource allocation, it is necessary to facilitate studies on the causes, prevention, or prognosis of these limitations [10]. Gross motor function and manual ability limitation are disturbed differently in the physiologic and topographic CP classifications. This study aims to determine the functional status of CP children and their relationship with the physiological and topographical classification of CP.

Materials and Methods

A cross-sectional non-interventional study was used to determine the functional status of children with CP and its relationship with the CP physiologic and topographic classification. The child's functional level was assessed by an examiner who was familiar with the scales and had received prior training in their use. Samples of the study consisted of children with CP aged between 4 and 18 years who were referred to all clinics, rehabilitation centers, and exceptional schools in Tehran and Arak.

The inclusion criteria for participants included children with CP aged 4–18 years old. On the other hand, participants were excluded from the study if they were unwilling to continue cooperating. All data were analyzed by IBM SPSS software, version 20.

Study instruments

Gross motor function classification system

The gross motor function classification system (GMFCS) is a standardized classification system that divides children with CP into five levels based on their current gross motor abilities. Level I shows the maximum independence, while Level V displays the least independence in performance. This scale was translated into Persian by Dehghan et al. [11].

Manual ability classification system

The manual ability classification system (MACS) is one of the most important tools, where the use of hands is classified as manipulating objects during everyday activities of children with CP. This scale offers a new perspective on the functional classification of manual ability in children and adults with CP, focusing on the severity of upper limb impairment. The child will be placed in one of the five MACS levels. These groupings are based on a child's ability to manipulate objects. Level I demonstrates the best manual ability, whereas level V shows a lack of active manual function. This scale is widely used and has been translated into Persian, with updates by Riyahi et al. [12].

Statistical analysis

The chi-square test of association was utilized to discover the relationship between categorical variables.

Results

The distribution of demographic information of participants is presented in Table 1. A total of 305 children with CP participated in this study, including 174 males (57%) and 131 females (43%).

The Pearson chi-square test was used to determine the relationship between topographical classification of CP and the acquired level of MACS and GMFCS in children with spastic CP (Table 2).

There was a statistically significant association between the topographical classification of CP and the acquired level of MACS (χ=82.436, P<0.01) and GMFCS (χ=103.331, P<0.01) in children with spastic CP.

The Pearson chi-square test was employed to find the relationship between the physiological classification of CP and the acquired level of MACS and GMFCS in children with CP (Table 3).

Based on the results, a statistically significant association was observed between the physiological classification of CP and the acquired level of MACS (χ=31.498, P<0.01) and GMFCS (χ=37.950, P<0.01) in children with CP.

Table 1. The distribution of demographic information of participants

Demographic Information		No. (%)
Gender	Boy	174(57)
	Girl	131(43)
	Total	305(100)
Age (y)	4-6	167(54.8)
	6-8	69(22.6)
	8-10	32(10.5)
	10-12	17(5.6)
	12-14	13(4.3)
	14-16	5(1.6)
	16-18	2(0.7)
Total		305(100)

The Pearson chi-square test was utilized to identify the relationship between the acquired level of GMFCS and the acquired level of MACS in children with CP (Table 4).

The results revealed a statistically significant association between GMFCS and MACS levels in children with CP (χ^2=247.271, P<0.01).

Discussion

This study evaluated the relationship between the functional status of children with CP and the topographical and physiological classifications of CP. Initially, the relationship between the topographical classification of CP and the acquired levels of MACS and GMFSC was investigated. Our results revealed a statistically significant correlation between the levels of the GMFCS and MACS in children with CP, which is in line with the results of other studies. For instance, Gorter et al. investigated the relationship between GMFCS, the distribution of limb involvement, and the type of motor disorder in 657 children with CP aged 1–13 years. They found that in children with diplegia (39% of the total), gross motor function is more limited than manual ability. Their findings showed a good distribution of MACS and GMFCS levels, suggesting that the spastic diplegia subgroup provides sufficient information regarding children's manual abilities and gross motor function [13].

The overall performance level decreases in both upper and lower extremities with an increase in the number of affected limbs. In hypotonic children, due to overall weakness, and in ataxic children, due to excessive movements and tremors, these characteristics appear to have had a more significant impact on hand function, resulting in lower MACS levels. In contrast, the accompanying characteristics in spastic, athetoid, and mixed children have had less effect on hand function, leading to higher MACS levels. Shi et al. evaluated the relationship between hand function limitation and the type of CP in 280 children with CP. A total of 195 children had cerebral palsy, most of whom were children with diplegia (56.41%). About 65% of spastic children acquired levels I and II of the MACS, while 84.44% of children with mixed CP and 80.95% of children with dyskinesia acquired levels III and IV. Children with spastic CP mostly had mild hand function limitations, while children with mixed and dyskinetic CP had moderate and severe hand function limitations [14]. In children with hypotonia, due to general weakness, and in children with ataxia, due to excessive movement and tremors, these features appear to have a greater impact on hand function, resulting in lower MACS scores. In children with ataxia, due to general weakness and tremors, these features appear to have had a more significant impact on hand function.

Golubović and Slavković studied the level of manual skills (capacity) and its relationship with manual abilities (performance). This cross-sectional study was performed on 30 children with CP aged 8–15 years. Their

Table 2. Cross-tabulation of topographical classification of CP and the acquired levels of MACS and GMFCS

Variables		No. (%)/% Topographical Classification Hemiplegia	Diplegia	Quadriplegia	Total
MACS I	In MACS	27(47.4)	27(47.4)	3(5.3)	57
	In total	11.5	11.5	1.3	24.3
MACS II	In MACS	26(41.9)	23(37.1)	13(21)	62
	In total	11.1	9.8	5.5	26.4
MACS III	In MACS	15(31.2)	10(20.8)	23(47.9)	48
	In total	6.4	4.3	9.8	20.4
MACS IV	In MACS	3(10)	12(40)	15(50)	30
	In total	1.3	5.1	6.4	12.8
MACS V	In MACS	1(2.6)	4(10.5)	33(86.8)	38
	In total	0.4	1.7	14	16.2
GMFCS I	In GMFCS	31(75.6)	7(17.1)	3(7.3)	41
	In total	13.2	3	1.3	17.4
GMFCS II	In GMFCS	23(43.4)	19(35.8)	11(20.8)	53
	In total	9.8	8.1	4.7	22.6
GMFCS III	In GMFCS	8(14.5)	31(56.4)	16(29.1)	55
	In total	3.4	13.2	6.8	23.4
GMFCS IV	In GMFCS	8(17.4)	14(30.4)	24(52.2)	46
	In total	3.4	6	10.2	19.6
GMFCS V	In GMFCS	2(5)	5(12.5)	33(82.5)	40
	In total	0.9	2.1	14	17

results confirmed a significant correlation between the acquired levels of MACS and GMFCS [15]. Likewise, Gajewska et al. evaluated the relationship between gross motor function, manual abilities, epilepsy, and mental capacity of children with cerebral palsy. This study was performed on 83 children with CP. They found a significant relationship between MACS and GMFCS [16]. Hidecker et al. studied 222 children with CP aged 2–17 years to examine the correlation between MACS, GMFCS, and the communication function classification system and observed a high correlation (R=0.49) between MACS and GMFCS levels [17]. Mutlu et al. investigated 448 children with CP aged 4–15 years to explore the relationship between MACS and GMFCS, reporting an overall agreement of 41%. The agreement was 42%, 40%, 60%, and 28% for spastic, dyskinetic, ataxic, and mixed children, respectively (K=0.235, P<0.001) [18].

In the present study, a greater number of participants were distributed at the same levels of MACS and GMFCS, indicating that gross motor function may influence manual ability and the acquired level of MACS. Therefore, it was observed that more participants were found at the same level within the MACS and GMFCS, highlighting a significant relationship between the two.

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Table 3. Cross-tabulation of physiological classification of CP and the acquired levels of MACS and GMFCS

Variables		No. (%)/%				Total
		Physiological Classification				
		Hypotonia	Spastic	Athetoid	Mixed	
MACS I	In MACS	5(8.1)	57(91.9)	0(0)	0(0)	62
	In total	1.6	18.8	0.0	0.0	20.4
MACS II	In MACS	8(11.1)	62(86.1)	1(1.4)	1(1.4)	72
	In total	2.6	20.4	0.3	0.3	23.7
MACS III	In MACS	16(23.5)	48(70.6)	4(5.9)	0(0)	68
	In total	5.3	15.8	1.3	0.0	22.4
MACS IV	In MACS	16(32)	30(60)	4(8)	0(0)	50
	In total	5.3	9.9	1.3	0.0	16.4
MACS V	In MACS	7(13.5)	38(73.1)	6(11.5)	1(1.9)	52
	In total	2.3	12.5	2.0	0.3	17.1
GMFCS I	In GMFCS	2(4.5)	41(93.2)	1(2.3)	0(0)	44
	In total	0.7	13.5	0.3	0.0	14.5
GMFCS II	In GMFCS	19(26)	53(72.6)	0(0)	1(1.4)	73
	In total	6.2	17.4	0.0	0.3	24
GMFCS III	In GMFCS	4(6.7)	55(91.7)	1(1.7)	0(0)	60
	In total	1.3	18.1	0.3	0.0	19.7
GMFCS IV	In GMFCS	10(16.7)	46(76.7)	4(6.7)	0(0)	60
	In total	3.3	15.1	1.3	0.0	19.7
GMFCS V	In GMFCS	17(25.4)	40(59.7)	9(13.4)	1(1.5)	67
	In total	5.6	13.2	3.0	0.3	22.0

Abbreviations: MACS: Manual abilities classification system; GMFCS: Gross motor function classification system; CP: Cerebral palsy.

This study revealed that the results of these systems align with the results of previous traditional classifications (e.g. topographic and physiological). The old systems place more emphasis on impairment and disability, while the new systems focus on individual abilities and performance in daily life.

Conclusion

These findings underscore the importance of understanding the relationship between the physiological classification of CP and its associated functional abilities. The significant correlations identified in our study indicated that targeted interventions can be designed to improve motor function and the overall quality of life for children with CP, particularly by addressing the specific needs associated with their classification levels.

One limitation of our study was the inadequate distribution in certain subgroups. It is recommended that further studies focus on exploring the performance, activity levels, and participation of school-aged children with CP and their relationship with the acquired levels of MACS and GMFCS.

Table 4. Cross-tabulation of GMFCS and MACS levels

Variables		No. (%)/% GMFCS					Total
		GMFCS I	GMFCS II	GMFCS III	GMFCS IV	GMFCS V	
MACS I	In MACS	26(41.9)	22(35.5)	13(21)	1(1.6)	0(0.0)	62
	In total	8.5	7.2	4.3	0.3	0.0	20.3
MACS II	In MACS	10(13.7)	29(39.7)	24(32.9)	9(12.3)	1(1.4)	73
	In total	3.3	9.5	7.9	3	0.3	23.9
MACS III	In MACS	7(10.3)	16(23.5)	16(23.5)	23(33.8)	6(8.8)	68
	In total	2.3	5.2	5.2	7.5	2	22.3
MACS IV	In MACS	1(2)	7(14)	6(12)	20(40)	16(32)	50
	In total	0.3	2.3	2	6.6	5.2	16.4
MACS V	In MACS	0(0.0)	0(0.0)	1(1.9)	7(13.5)	44(84.6)	52
	In total	0.0	0.0	0.3	2.3	14.4	17.0

MACS: Manual abilities classification system; GMFCS: Gross motor function classification system.

Ethical Considerations

Compliance with ethical guidelines

The approval was obtained from the Ethics Committee of Arak University of Medical Sciences, Arak, Iran (Code: IR.ARAKMU.REC.1395.188). Informed written consent was obtained from all parents.

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Authors' contributions

Conceptualization: Azade Riyahi, Hosseinali Abdolrazaghi, and Zahra Nobakht; Funding acquisition: Azade Riyahi; Resources: Azade Riyahi; Investigation: Azade Riyahi; Methodology: Hosseinali Abdolrazaghi; Data curation: Hosseinali Abdolrazaghi; Formal analysis: Zahra Nobakht; Software: Hosseinali Abdolrazaghi; Supervision: Azade Riyahi; Validation: Azade Riyahi; Visualization: Azade Riyahi; Writing the original draft: Zahra Nobakht; Review and editing: Zahra Nobakht.

Conflict of interest

The authors declared no conflict of interest.

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