

Measurement of the Effect of Dietary Planning on Nutritional Status in Children with Cerebral Palsy

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ABSTRACT

Background

Children with cerebral palsy (CP) are at high risk of malnutrition due to feeding difficulties, increased energy requirements, and associated comorbidities. Nutritional management is therefore a critical component of their overall care.

Objective

This study aimed to evaluate the effect of individualized diet planning on the nutritional status of children with CP.

Methods

A total of 68 patients with cerebral palsy (CP) were initially enrolled in this interventional study, of whom 40 completed the study. Data were collected through caregiver interviews, including demographic characteristics, clinical status, and feeding behaviors. Nutritional assessment comprised anthropometric measurements, biochemical parameters, and dietary intake evaluation using a Food Frequency Questionnaire (FFQ) and 24-hour dietary recall. Individualized diet plans were developed for each participant, and follow-up assessments were conducted after three months to evaluate the intervention outcomes.

Results

Feeding difficulties were highly prevalent among participants, particularly prolonged feeding time (70%) and difficulty in chewing (65%). After three months of dietary intervention, significant improvements were observed in all anthropometric parameters, including weight Z-score, BMI, mid-arm circumference, and skinfold thickness ($p < 0.001$). Hematological and biochemical parameters also improved significantly, including hemoglobin, hematocrit, MCV, MCH, serum ferritin, albumin, and calcium levels ($p < 0.05$). Improvements were consistent across most CP types. No significant correlation was found between CP type and nutritional or biochemical parameters.

Conclusion

Individualized diet planning significantly improves the nutritional and hematological status of children with CP. Early nutritional assessment and tailored dietary interventions are essential components in the comprehensive management of these patients to enhance growth, health outcomes, and quality of life.

Keywords: Cerebral palsy; Nutritional status; Diet planning; Anthropometry; Hematological parameters; Dietary intervention

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Introduction:

Cerebral palsy (CP) is the most common childhood-onset physical disability worldwide and is frequently associated with feeding difficulties, oropharyngeal dysphagia, gastrointestinal problems and altered

energy expenditure, which place children at high risk of malnutrition and growth failure.¹

Reported prevalence of undernutrition in CP ranges from about 40% to over 60%, with high rates of underweight, stunting, and thinness, particularly among children with more severe motor impairment

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and in low- and middle-income settings. Malnutrition in CP is associated with increased morbidity and mortality, poorer immune function, reduced participation, and lower quality of life for both patients and families.²

Nutritional problems in CP are multifactorial. Swallowing disorders, oral–facial malformations, lack of lip closure, and prolonged or unsafe mealtimes directly compromise dietary intake and are strongly associated with poor anthropometric indices.³

Inappropriate feeding positions, suboptimal food consistency, and low dietary diversity further limit energy and nutrient intake, while chronic gastrointestinal conditions such as reflux and constipation are common and can exacerbate undernutrition. At the same time, a subset of children with milder motor impairment experience excess adiposity when energy intake exceeds reduced activity levels, highlighting the need for individualized nutritional assessment and planning.⁴

Evidence suggests that structured nutrition interventions and diet planning can improve clinical and nutritional outcomes in CP. Systematic review of randomized trials has identified benefits of energy-dense diets, tailored enteral formulas, micronutrient supplementation, and caregiver education on anthropometry, micronutrient status, gastrointestinal symptoms, and functional outcomes, though overall trial quality remains low.⁵

Observational and interventional studies of individualized nutrition protocols, aligned with pediatric gastroenterology guidelines, report significant improvements in weight, BMI, skinfolds, and mid-upper arm circumference over 6–12 months, with reductions in the proportion of undernourished children. In low- and middle-income countries, interventions that directly modify diet composition and feeding practices (e.g., dietary modification, caregiver training, or gastrostomy when indicated) appear more effective for improving nutritional status than behavioral approaches alone.⁶

Despite these advances, recent reviews emphasize substantial knowledge and practice gaps; many CP services lack standardized approaches to nutritional assessment, food texture modification, and diet planning; robust evidence to guide context-specific protocols, particularly in resource-limited settings, is still limited.⁷ Developing and evaluating systematic diet planning strategies tailored to the functional level, feeding abilities, and comorbidities of individuals with CP is therefore a priority to optimize nutritional

status and long-term health outcomes.⁸ On the basis above, this study was conducted aiming to assess the impact of diet planning on nutritional status and body composition of patients with CP.

Patients and methods:

Study Design

This study was conducted over a period of three months. All children attending the physical therapy rehabilitation clinic at October 6 University Hospital within the period between September –December 2025 who fulfilled the inclusion criteria were recruited,

The research followed an interventional-follow-up study design aiming at evaluation of the nutritional status and impact of individualized dietary planning among children diagnosed with CP based on the dietary guidelines for Americans.⁹ The study was conducted in accordance to the declaration of Helsinki, and the study protocol was approved by the Ethical Committee of the Faculty of Medicine, October 6 University. The study objectives were explained to the parents of all participating children, and written informed consent was obtained prior to inclusion. Data confidentiality was strictly maintained throughout the study, and no additional risks were imposed on the participants.

Study Population

The study included 68 patients, 40 of them completed the 3-month dietary intervention. Participants were considered eligible for inclusion in this study if they had a confirmed diagnosis of CP based on clinical medical evaluation and documented records, were younger than 12 years at the time of enrollment and were actively receiving at least one form of rehabilitation therapy, including physical therapy, occupational therapy, or speech therapy. Children were excluded from the study if they had coexisting genetic or metabolic disorders that required specialized medical nutrition therapy, particularly conditions necessitating the use of specific therapeutic formulas or specialized dietary regimens.

Medical History and socio-demographic characteristics

Detailed medical history and demographic data were collected from caregivers through structured face-to-face interviews using a standardized questionnaire. The collected information included age, gender, residence, birth order, history of parental consanguinity, family history, and age at diagnosis of CP. Clinical and nutritional characteristics were also assessed, including the presence of food allergies or

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intolerances, food aversions, adherence to special diets, and the use of nutritional supplements or dietary formulas. Furthermore, information regarding regular medication use, disease-related complications and comorbidities was obtained, including epilepsy, musculoskeletal problems, intellectual disability, feeding difficulties, visual abnormalities, hearing impairment, and communication difficulties as described by Zhao J, Qiu Y, Su J (2025).¹⁰

Nutritional Assessment

A comprehensive nutritional assessment was conducted, encompassing anthropometric, biochemical, and dietary intake evaluations. Measurements were obtained at baseline and after three months to assess the impact of dietary planning on the nutritional status of participants.

Anthropometric Assessment

Anthropometric measurements were performed using standardized techniques and calibrated instruments to ensure accuracy and reliability. The assessed parameters included body weight and length/height. Each measurement was taken twice, and the average value was recorded to minimize measurement error. The obtained measurements were plotted on age- and sex-specific Egyptian growth charts to evaluate growth status relative to the reference population. Nutritional status was interpreted according to the World Health Organization (WHO) growth standards (2006) using Z-score classifications. Stunting was defined as height-for-age Z-score (HAZ) ≤ -2 standard deviations (SD), underweight as weight-for-age ≤ -2 SD, overweight as BMI-for-age Z-score $\geq +2$ SD, and obesity as BMI-for-age Z-score $\geq +3$ SD.¹¹

In addition to basic anthropometric measurements, skinfold thickness was measured to estimate body fat percentage. Measurements were taken at the biceps, triceps, and subscapular regions using standardized techniques as described by Lohman (1998).¹²

Biochemical Assessment

Venous blood samples were collected from all participants for laboratory analysis. Hematological parameters included hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). Nutritional biomarkers assessed were serum ferritin, serum albumin, total serum calcium, and ionized serum calcium. These investigations were conducted to evaluate nutritional deficiencies, anemia, and micronutrient status among participants. All laboratory parameters were measured at baseline and

after three months to assess changes following the dietary intervention following specific standardized techniques for each biomarker as described by WHO (World Health Organization).¹³

Clinical evaluation

Clinical evaluation to establish the type of CP based on the dominant motor disturbance and topography of motor signs, which are categorized as spastic (diplegia, hemiplegia, quadriplegia), dyskinetic, ataxic, or mixed. In this study, the confirmed diagnosis and classification of CP types were retrieved from the patient's documented clinical medical records.¹⁴

Dietary Intake and Feeding Assessment

Dietary intake and feeding practices were evaluated through caregiver interviews. Information collected included the number of daily meals, frequency and type of snacks, meal timing, and the presence of meal skipping. Feeding practices were also assessed in detail, including food preparation methods, food texture and consistency, feeding position, utensils used during feeding, time required for feeding, feeding difficulties, and the presence of swallowing problems.

Dietary intake adequacy was assessed using two validated dietary assessment methods: the Food Frequency Questionnaire (FFQ) and the 24-hour dietary recall method. The FFQ was used to evaluate the participants' average dietary intake over the previous month. It was administered through face-to-face interviews with caregivers using a previously validated questionnaire designed for Egyptian children.¹⁵ This tool enabled the assessment of the frequency of consumption of various food groups and commonly consumed food items.

In addition, the 24-hour dietary recall method was employed to estimate individual nutrient intake during face-to-face interviews (including portion sizes and methods of food preparation). To improve the accuracy of portion size estimation, Two-Dimensional Food Portion Visuals (2DFPV) were utilized. This validated tool consists of double-sided charts presenting two-dimensional illustrations of common household measures, which assist caregivers in accurately estimating portion sizes.¹⁶ The portion sizes obtained from the visual charts were subsequently converted into gram weights using food density tables provided by the Food and Agriculture Organization (FAO, 2012), enabling quantitative estimation of nutrient intake.

Diet Planning Intervention

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Based on the findings of the nutritional assessment and dietary intake evaluation a personalized printed meal plan was provided for each participant. Each meal plan was based on the specific calculated energy, protein, nutrient requirements, dietary preferences and specific modifications in consistency and texture needed for each child to improve total energy intake, ensure adequate consumption of macronutrients and micronutrients, address feeding difficulties, and enhance overall nutritional status. Energy requirements were estimated using standard pediatric predictive equations and adjusted for mobility level and muscle tone in children with CP, in accordance with ESPGHAN recommendations.¹⁷ Protein requirements were calculated based on Dietary Reference Intakes (DRIs) and further adjusted according to nutritional status and clinical needs.¹⁸ Caregivers received structured nutritional education, which included guidance on appropriate meal composition, modification of food consistency, and feeding techniques tailored to children with cerebral palsy.

Participants were followed for a period of three months, after which anthropometric and biochemical parameters were reassessed to evaluate the effectiveness of dietary intervention.

Statistical Analysis:

The IBM Statistical Package for the Social Sciences, version 20.0 (Armonk, NY: IBM Corp.), was used for the statistical analysis. Quantitative variables were shown as the mean \pm standard deviation, median, and range (minimum-maximum) based on data distribution, whilst qualitative factors were condensed into percentages and frequencies. We used the Kolmogorov-Smirnov test to get a feel for how normally distributed the quantitative variables were. We used the Chi-square test to compare the two sets of categorical variables. When dealing with quantitative variables, the independent two-sample t-test was utilized for data that followed a normal distribution, and the Mann-Whitney U test was utilized for data that did not. When necessary, we used Spearman's correlation coefficient to analyze the correlations. To assess factors that could be used to forecast clinical results, regression analyses were carried out. We utilized logistic regression models, both univariate and multivariate, to analyze binary outcomes. The results, presented as odds ratios (OR) with 95% CI, were considered reliable and accurate. Unstandardized beta coefficients (η) were used to express the results of linear regression models applied

to continuous outcomes. We considered $p < 0.05$ to be statistically significant.

Results:

Table 1: Descriptive analysis of Children with Cerebral Palsy (n = 40)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	Mean \pm SD	9.2 \pm 2.37	—
Age Group (years)	<5	2	5%
	5-10	24	60%
	>10	14	35%
Consanguinity	Yes	18	45%
	No	22	55%
Order of Birth	First	16	40%
	Second	14	35%
	Third or more	10	25%
Clinical Characteristics			
Type of CP	Spastic diplegia	17	42.50%
	Spastic quadriplegia	16	40%
	Hemiplegia	4	10%
	Extrapyramidal	3	7.5%
Cause of CP	Hypoxia	20	50%
	Hemorrhage	20	50%
Associated Conditions	Mental retardation	13	32.50%
	Visual impairment	8	20%
	Epilepsy	8	20%
	None	11	27.50%
Similar Conditions in the Family	Yes	23	57.50%
	No	17	42.50%
Symptom of Feeding Difficulty			
Difficulty chewing		26	65%
Difficulty swallowing (Dysphagia)		22	55%
Drooling (Sialorrhea)		24	60%
Prolonged feeding time (>30 min)		28	70%
Food refusal		18	45%
Choking episodes		16	40%
Poor appetite		20	50%
Gastroesophageal reflux symptoms		14	35%
Vomiting during/after feeding		12	30%

CP: Cerebral Palsy

Our research included 40 children with CP. Participants' average age was 9.2 ± 2.37 years, and most of them (60%) were between 5 and 10 years old. The study included 21 males (48.8%) and 22 females (51.2%). Spastic diplegia and spastic quadriplegia were the predominant forms in 42.5% and 40% respectively. Regarding associated conditions, 32.5% were mentally retarded, followed by visual impairment and epilepsy (20% each). Feeding problems were very common in the patients studied as shown in Table 1.

Clinical Characteristic	Spastic Diplegia (n = 17)	Spastic Quadriplegia (n = 16)	Hemiplegia (n = 4)	Extrapyramidal (n = 3)
Cause of CP				
Hypoxia	7 (41.2%)	10 (62.5%)	1 (25.0%)	2 (66.7%)
Hemorrhage	10 (58.8%)	6 (37.5%)	3 (75.0%)	1 (33.3%)
Associated Conditions				
Mental retardation	9 (64.3%)	1 (10.0%)	2 (50.0%)	1 (100%)
Epilepsy	2 (14.3%)	4 (40.0%)	2 (50.0%)	0 (0.0%)
Visual impairment	3 (21.4%)	5 (50.0%)	0 (0.0%)	0 (0.0%)
Similar Conditions in the Family				
Yes	9 (52.9%)	10 (62.5%)	2 (50.0%)	2 (66.7%)
No	8 (47.1%)	6 (37.5%)	2 (50.0%)	1 (33.3%)

Statistical test used: Two sample T-test
p-value ≤ 0.05 considered statistically significant (95% confidence interval).

CP: Cerebral Palsy

Table 2: Clinical Characteristics of Children According to Type of Cerebral Palsy (n = 40)

Regarding the cause of CP, hypoxia was predominantly reported in extrapyramidal cases (66.7%). Associated conditions were distributed variably among the different CP types (Table 3).

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Variable	Baseline (Mean ± SD)	After 3 Months (Mean ± SD)	p-value
Anthropometric Measurements			
Weight Z-score	-1.89 ± 0.69	-1.46 ± 0.65	<0.001
Height/Length Z-score	-1.65 ± 0.68	-1.31 ± 0.71	<0.001
BMI (kg/m ²)	14.30 ± 0.66	14.78 ± 0.67	<0.001
Mid Arm Circumference (cm)	14.68 ± 1.71	14.92 ± 1.74	<0.001
Skin Fold Thickness (mm)	9.66 ± 2.73	9.88 ± 2.74	<0.001
Hematological Parameters			
Hb (g/dL)	10.22 ± 0.80	10.78 ± 0.85	0.001*
Hematocrit (%)	34.06 ± 2.35	35.78 ± 2.42	0.002*
MCV (fL)	73.87 ± 3.31	75.22 ± 3.18	0.010*
MCH (pg)	25.01 ± 1.80	26.08 ± 1.76	0.004*
Serum Ferritin (ng/mL)	16.91 ± 4.68	19.63 ± 4.95	0.003*
Serum Albumin (g/dL)	3.66 ± 0.46	3.89 ± 0.44	0.012*
Calcium Total (mg/dL)	9.18 ± 0.39	9.36 ± 0.41	0.021*
Calcium Ionized (mmol/L)	1.15 ± 0.05	1.19 ± 0.06	0.018*

* p-value ≤ 0.05 considered statistically significant (95% confidence interval)

BMI: Body Mass Index, Hb: Hemoglobin, MCV: Mean Corpuscular Volume, MCH: Mean Corpuscular Hemoglobin

Table 3: Comparison of Anthropometric Measurements & Hematological Parameters Before and After Diet Planning (n = 40)

After three months of diet planning, anthropometric measurements exhibited significant improvement, evidenced by substantial increases in weight Z-score, height/length Z-score, BMI, MUAC, and skin fold thickness (all p < 0.001). Hematological parameters, such as hemoglobin, hematocrit, MCV, and MCH, also improved significantly. There were also statistically significant increases in nutritional biomarkers like serum ferritin, albumin, and both total and ionized calcium (Table 3).

Table 2: Comparison of Anthropometric Measurements Before and After Diet Planning According to CP Type

Parameter	CP Type	Baseline (Mean ± SD)	After 3 Months (Mean ± SD)	p-value
Z score	Spastic Diplegia	-1.83 ± 0.73	-1.42 ± 0.67	<0.001
	Spastic Quadriplegia	-1.90 ± 0.69	-1.47 ± 0.68	<0.001
	Hemiplegia	-2.15 ± 0.42	-1.75 ± 0.37	0.002
	Extrapyramidal	-1.80 ± 0.98	-1.30 ± 0.87	0.082
	Spastic Diplegia	-1.41 ± 0.68	-1.07 ± 0.77	<0.001
Z score	Spastic Diplegia	-1.84 ± 0.59	-1.51 ± 0.56	<0.001
	Hemiplegia	-1.95 ± 0.83	-1.63 ± 0.80	0.001
	Extrapyramidal	-1.50 ± 0.87	-1.13 ± 0.84	0.008
	Spastic Diplegia	14.34 ± 0.68	14.80 ± 0.70	<0.001
	Spastic Quadriplegia	14.39 ± 0.61	14.88 ± 0.60	<0.001
m Circumference (cm)	Hemiplegia	13.85 ± 0.39	14.33 ± 0.45	0.005
	Extrapyramidal	14.17 ± 1.11	14.70 ± 1.11	0.004
	Spastic Diplegia	15.01 ± 1.80	15.22 ± 1.87	<0.001
	Spastic Quadriplegia	14.18 ± 1.77	14.44 ± 1.78	<0.001
	Hemiplegia	14.93 ± 1.06	15.22 ± 1.15	0.015
old Thickness (mm)	Extrapyramidal	15.20 ± 1.56	15.40 ± 1.55	0.051
	Spastic Diplegia	9.20 ± 3.10	9.39 ± 3.13	<0.001
	Spastic Quadriplegia	9.54 ± 2.03	9.78 ± 2	<0.001
	Hemiplegia	10.30 ± 2.04	10.59 ± 2.14	0.014
	Extrapyramidal	12.03 ± 4.53	12.22 ± 4.53	0.031

* p-value ≤ 0.05 considered statistically significant (95% confidence interval)

rebral Palsy, BMI: Body Mass Index

Table 4 indicates that anthropometric parameters improved in the majority of CP types after three months of dietary planning. In children with spastic diplegia, spastic quadriplegia, and hemiplegia, there were significant improvements in weight Z-score, height Z-score, BMI, MUAC, and skin fold thickness (p < 0.05). While improvements observed in children with extrapyramidal CP, including weight Z-score and MUAC, failed to achieve statistical significance.

Table 3: Comparison of Hematological Parameters Before and After Diet Planning According to CP Type

Parameter	CP Type	Baseline (Mean ± SD)	After 3 Months (Mean ± SD)	p-value
HB (g/dL)	Spastic Diplegia	10.31 ± 0.82	10.89 ± 0.87	0.003*
	Spastic Quadriplegia	10.14 ± 0.77	10.66 ± 0.79	0.004*
	Hemiplegia	10.05 ± 0.69	10.45 ± 0.71	0.041*
	Extrapyramidal	10.26 ± 0.91	10.58 ± 0.95	0.049*
Serum Ferritin (ng/mL)	Spastic Diplegia	17.54 ± 4.71	20.66 ± 4.92	0.005*
	Spastic Quadriplegia	16.42 ± 4.53	19.11 ± 4.67	0.006*
	Hemiplegia	15.98 ± 4.29	18.32 ± 4.41	0.048*
	Extrapyramidal	16.87 ± 4.62	18.95 ± 4.88	0.045*
Serum Albumin (g/dL)	Spastic Diplegia	3.71 ± 0.45	3.96 ± 0.44	0.018*
	Spastic Quadriplegia	3.61 ± 0.47	3.83 ± 0.46	0.021*
	Hemiplegia	3.55 ± 0.42	3.72 ± 0.40	0.046*
	Extrapyramidal	3.66 ± 0.51	3.84 ± 0.49	0.043*
Calcium (Total) (mg/dL)	Spastic Diplegia	9.21 ± 0.38	9.39 ± 0.41	0.027*
	Spastic Quadriplegia	9.14 ± 0.41	9.32 ± 0.40	0.031*
	Hemiplegia	9.10 ± 0.36	9.24 ± 0.35	0.049*
	Extrapyramidal	9.19 ± 0.42	9.33 ± 0.43	0.044*

* p-value ≤ 0.05 considered statistically significant (95% confidence interval).

CP: Cerebral Palsy, Hb: Hemoglobin

Table 5 shows that after three months of planning a diet, there were significant improvements in biochemical tests for all types of CP.

Table 4: Correlation Between Type of Cerebral Palsy and Anthropometric Measurements & Biochemical Parameters

Nutritional Parameter	r	p-value
Weight (kg)	-0.198	0.22
Height (cm)	-0.271	0.091
Weight Z score	-0.061	0.706
Height Z score	-0.073	0.654
BMI	-0.085	0.601
Mid Arm Circumference (cm)	0.071	0.661
Skin Fold Thickness (mm)	0.213	0.186
Biochemical Parameter		
Hemoglobin (HB)	0.121	0.456
Hematocrit	0.218	0.176
MCV	0.153	0.345
MCH	0.168	0.3
Serum Ferritin	0.079	0.628
Serum Albumin	0.186	0.25
Calcium (Total)	0.194	0.231
Calcium (Ionized)	0.102	0.531

* p-value ≤ 0.05 considered statistically significant (95% confidence interval)

BMI: Body Mass Index, Hb: Hemoglobin, MCV: Mean Corpuscular Volume, MCH: Mean Corpuscular Hemoglobin

Table 6 indicates that there were no statistically significant correlations between the type of CP and any of the anthropometric or biochemical parameters (all p > 0.05). Some weak positive and negative correlations were noted, none achieved statistical significance, suggesting that the type of cerebral palsy did not significantly influence nutritional status or biochemical markers in this study population.

Discussion:

In CP, nutritional status is not merely a background variable, it is a modifiable determinant of infection risk, bone health, rehabilitation participation, wound healing, and caregiver burden, making it central to outcome evaluation in diet planning studies.⁵

The present study investigated nutritional status and the impact of individualized dietary planning intervention among children with CP, using demographic, anthropometric, and biochemical indicators.

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In our study, feeding difficulties and swallowing problems were highly prevalent among the participants. This is consistent with the findings of Mokhlesin et al. (2024) who reported feeding disorders in 79.2% and swallowing difficulties in 78.3% in children with CP, with a high prevalence of GERD and strong associations between swallowing severity, malnutrition, and motor impairment¹⁹. Feeding difficulties and dysphagia reduce intake and can make meals prolonged, stressful, and unsafe. Oral and pharyngeal discoordination is a major driver of reduced intake in CP, with prolonged feeding times and spillage reducing effective calories even when food is offered. Feeding difficulty can translate quickly into chronic caloric deficit and micronutrient gaps, especially in resource-limited settings.²⁰ As dysphagia can lead to silent aspiration and recurrent respiratory illness, it is a major determinant of whether nutrition plans must include texture modification, thickened fluids, feeding pacing strategies, or enteral feeding.²¹

Individualized diet planning over three months led to significant improvements in all anthropometric indicators among our participants. Katseni et al. (2021) similarly reported that an individualized nutrition intervention protocol for neurologically impaired pediatric patients (the majority with CP) produced significant improvements in weight-for-age, BMI, MUAC and triceps skinfold Z-scores over 6–12 months and reduced the proportion of underweight and stunted children²².

Nutritional interventions for children with CP in low- and middle-income countries, concluded that dietary modification and growth-focused feeding strategies generally had more favorable impacts on nutritional outcomes than isolated behavioral or skills-based interventions.⁴

In our investigation, three months of individualized diet planning reflected in significant improvement in all hematological and biochemical parameters among children with CP including mean Hb, HCT, and both MCV and MCH. Iron status improved, as reflected by the rise in serum ferritin. Furthermore, serum albumin and both total and ionized calcium levels increased significantly, indicating better overall protein–energy and micronutrient status.

This is in accordance with Rebelo et al. (2022) who reported that targeted nutrition interventions—such as lipid mixture supplementation, high–energy-density diets, and specific micronutrient therapies (e.g., lactoferrin plus iron, vitamin D)—produced

significant improvements in biochemical markers including hemoglobin, ferritin, 25-hydroxyvitamin D, and calcium homeostasis parameters⁶.

In the present study, anthropometric assessment across CP subtypes showed only modest variation. Children with spastic quadriplegia had the highest mean body weight and height, whereas those with hemiplegia had the lowest. Other measurements were relatively similar across all CP types. However, none of these differences reached statistical significance, suggesting a broadly comparable nutritional status among CP subtypes.

Energy needs in CP are heterogeneous, some children have reduced total energy needs due to low activity and reduced lean mass, while others expend more energy during movement because of inefficiency from spasticity or dystonia. Guidance for neurologic impairment stresses individualized energy assessment and notes that standard dietary reference intakes (DRIs) can overestimate requirements in children with severe growth delay and lower muscle mass.²³

Hematological and biochemical profiles were broadly comparable across CP subtypes. Hemoglobin levels increased significantly in all groups with highest value in extrapyramidal CP. Indices of red blood cell morphology (MCV, MCH) showed only minor variation between types. Serum ferritin and albumin levels were also relatively similar, with slightly higher ferritin values in extrapyramidal cases, and total and ionized calcium levels differed minimally between groups. None of these inter-type differences were statistically significant ($p > 0.05$).

Micronutrients deficiency in children with CP due to poor oral intake, limited dietary diversity, tube feeding, or long-term medications impacting absorption/metabolism.²⁴

ESPGHAN guidance highlights that micronutrient deficiencies (e.g., calcium, iron, zinc, vitamins C, D, E, selenium) may be common in neurologic impairment and recommends micronutrient monitoring strategies (including routine checks in some contexts), particularly for those with chronic feeding problems or tube feeding.^{17, 25}

Significant improvements in anthropometric indicators across all CP types were noticed after 3-month dietary intervention in our research. Children with spastic diplegia, spastic quadriplegia, and hemiplegia showed statistically significant improvements in weight Z score, whereas

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extrapyramidal cases showed a non-significant trend toward improvement.

Energy requirements in CP vary markedly with mobility, muscle tone, activity, and growth velocity. ESPGHAN guidance for neurologic impairment states that there are no single CP-specific energy recommendations suitable for all; energy needs should be assessed individually using DRIs. Children dependent on wheelchairs may require substantially less energy than typically developing peers, while ambulatory children may require more energy for walking.²⁶

In the present study, dietary intervention produced significant improvements in hematological and biochemical indicators across all CP types. Hemoglobin concentrations increased in every subgroup, with mean values rising by approximately 0.4–0.6 g/dL over three months. Parallel statistically significant gains were observed in serum ferritin, albumin, and total calcium levels.

Rebello et al. (2022), reported that supplementation with lactoferrin and an iron hydroxide polymaltose complex in Egyptian children with CP suffering iron deficiency anemia led to significant increases in hemoglobin and ferritin. Similarly, high-energy diets and lipid mixtures were associated with improvements in anthropometric and some biochemical markers. Active nutritional strategies, whether pharmacologic (iron preparations) or dietary (planned diets), can correct hematological deficits and improve iron stores in CP populations.⁶

Comparing dietary interventions with iron supplementation in individuals with iron deficiency, in anemic or iron-deficient children, demonstrated that iron supplementation produced larger increases in hemoglobin than dietary modification alone, although both approaches improved iron-status markers.²⁷

In the present study, CP phenotype was not significantly correlated with any anthropometric indicator. Huysentruyt et al. (2020) reported a strong gradient of anthropometric impairment with increasing motor severity rather than phenotype where all anthropometric indices (weight-for-age Z score, MUAC Z score, and skinfold Z scores) declined with increasing Gross Motor Function Classification System (GMFCS) level, indicating poorer nutritional status in more severely affected children ($p < 0.001$)²⁸. Furthermore, no statistically significant correlations were found between CP type and any of the evaluated biochemical indicators. Only weak positive associations were observed with hemoglobin,

hematocrit, MCV, MCH, serum ferritin, serum albumin, total calcium, and ionized calcium, all with $p > 0.05$. Chamova et al. (2025) found positive correlations between hemoglobin, serum iron, ferritin, albumin, and anthropometric Z-scores, suggesting that biochemical markers primarily reflect overall nutritional status rather than CP phenotype.²⁹

The fact that individualized dietary plans were developed for each participant is a strength of our study. Every caregiver received structured nutritional education separately, and they are regularly followed up for 3 months. We also included all types of CP in our study.

Since our participants were followed throughout a period of three months, our study had some limitations. Longer follow-up periods are recommended to investigate the improvement of anthropometric and biochemical parameters. Also, our sample size was small.

Conclusion

Individualized dietary planning and education had a positive impact on the nutritional status of children with CP. The dietary intervention resulted in improvements in both anthropometric measurements and biochemical parameters, indicating better nutritional intake and metabolic status. These findings highlight the importance of early nutritional assessment and individualized diet planning as essential components in the comprehensive management of children with CP. Proper nutritional support can contribute to improved growth, better health outcomes, and enhanced quality of life for affected children.

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