



## ORIGINAL ARTICLE

## Nutritional aspects in patients with cerebral palsy: A multicenter observational study in Spain

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**KEYWORDS**

Cerebral palsy;  
Comorbidities;  
GMFCS;  
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Nutritional support

**Abstract**

**Introduction:** Cerebral palsy (CP) encompasses a group of motor disorders that can result in swallowing difficulties, affecting food intake and contributing to poor nutritional status. The goal of the study was to describe the clinical and nutritional characteristics of Spanish children with CP.

**Methods:** Multicenter observational study conducted in children aged 4–14 years with a diagnosis of CP. For every patient, we collected data on sociodemographic and clinical characteristics as well as anthropometric measurements, schooling modality, nutrition received at school, nutritional support and gastrointestinal comorbidities.

**Results:** The sample included a total of 112 patients with a mean age of 9.2 years old. The majority (70.5%) had been classified as Gross Motor Function Classification System (GMFCS) level IV or V. Compared to children classified as GMFCS level I, II or III, the group of children with GMFCS level IV/V had significantly lower mean z scores in body weight, height, weight-to-height ratio, body mass index and upper arm circumference and a significant lower mean arm area. A higher proportion of patients with GMFCS level IV/V attended special education schools compared to patients classified as level I to III (68.4% vs. 12.1%;  $P < .0001$ ). A higher proportion of children classified as level IV/V compared to children classified as levels I to III presented dysphagia (62.0% vs. 15.2%;  $P < .0001$ ), constipation (51.9% vs. 27.3%,  $P = .0218$ ) and gastroesophageal reflux (31.6% vs. 3.0%;  $P = .0005$ ).

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<sup>1</sup> Appendix 1 lists the members of the Multidisciplinary Working Group on Cerebral Palsy who collaborated in the study.

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**PALABRAS CLAVE**

Parálisis cerebral;  
Comorbilidades;  
GMFCS;  
Estado nutricional;  
Apoyo nutricional

**Conclusions:** Our study shows that Spanish children with CP, especially those with severe motor impairment, are at risk of malnutrition, present gastrointestinal comorbidities and require nutritional support.

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### Aspectos nutricionales de los pacientes con parálisis cerebral: un estudio observacional y multicéntrico en España

#### Resumen

**Introducción:** La parálisis cerebral (PC) abarca un grupo de trastornos motores que pueden resultar en dificultades para tragar, afectando la ingesta de alimentos y contribuyendo a un deterioro del estado nutricional. El objetivo del estudio fue describir las características clínicas y nutricionales de los niños españoles con PC.

**Métodos:** Estudio observacional multicéntrico realizado en niños de 4 a 14 años diagnosticados de PC. Se recopilieron datos sociodemográficos y clínicos, así como medidas antropométricas, modalidad escolar, nutrición recibida en la escuela, apoyo nutricional y comorbilidades gastrointestinales de todos los pacientes.

**Resultados:** Se incluyó un total de 112 pacientes con una edad media de 9,2 años. Un 70,5% presentaba un grado IV-V en el Sistema de Clasificación de la Función Motora Gruesa (GMFCS). En comparación con aquellos con GMFCS I-II-III, los niños con grados IV-V del GMFCS mostraron una puntuación z media significativamente menor en peso, talla, relación peso/talla, índice de masa corporal y circunferencia del brazo, y un área del brazo significativamente menor. Una proporción mayor de pacientes con GMFCS IV-V asistió a escuelas de educación especial en comparación con pacientes con GMFCS I-II-III (68,4% vs. 12,1%,  $p < 0,0001$ ). Una mayor proporción de niños con GMFCS IV-V presentó disfagia (62,0% vs. 15,2%,  $p < 0,0001$ ), estreñimiento (51,9% vs. 27,3%,  $p = 0,0218$ ) y reflujo gastroesofágico (31,6% vs. 3,0%,  $p = 0,0005$ ) en comparación con niños con GMFCS I-II-III.

**Conclusiones:** Nuestro estudio muestra que los niños españoles con PC, especialmente aquellos con mayor deterioro motor severo, están en riesgo de desnutrición, presentan comorbilidades gastrointestinales y requieren apoyo nutricional.

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## Introduction

The term cerebral palsy (CP) describes a heterogeneous group of disorders of movement and posture characterized by abnormal muscle tone, posture and movement that limit the activity of the affected individual and attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain.<sup>1,2</sup> The motor disorders of CP are often accompanied by disorders of sensation, perception, cognition, communication and behavior, epilepsy and secondary musculoskeletal problems.<sup>1</sup> While the motor disorder is persistent, the clinical manifestations can change over the course of disease.<sup>2,3</sup> The global prevalence of CP in high-income countries is of approximately 2 per 1000 live births, and it is estimated to be higher in low- and middle-income countries.<sup>3</sup>

The diagnosis of CP is essentially clinical and based on neurological examination and motor evaluation findings, the presence of any of the main risk factors associated with CP and neuroimaging and head magnetic resonance imaging features.<sup>4,5</sup> The severity of CP can be graded using the

Gross Motor Function Classification System (GMFCS), which establishes the level of motor function or impairment.<sup>6</sup> In children with CP, especially those classified at higher GMFCS levels, motor function impairment is associated with a high risk of swallowing difficulties<sup>7</sup> that affect food intake<sup>8,9</sup> and contribute to poor nutritional status. Motor disability can promote the development of dysphagia,<sup>10</sup> which is estimated to affect almost all children with severe CP,<sup>11</sup> can affect swallowing safety and efficacy and can result in poor nutritional status and respiratory tract infection due to recurrent bronchial aspiration.<sup>11,12</sup> Consequently, the prevalence of undernutrition among children with CP is high overall (approximately 40%) and even greater in those with more severe motor impairment.<sup>7,9</sup> As a result, children with CP might have decreased bone density and muscle mass, leading to decreased functional status.<sup>7</sup> Children with swallowing difficulties or dysphagia might require nutritional support to overcome undernutrition.<sup>13</sup> In this regard, previous studies have shown that nutritional support can achieve weight gain and improved nutritional status in these patients.<sup>14,15</sup>

Although nutritional assessment and intervention in these patients can be challenging, it should be part of their care. In this context, the guidelines of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) recommend routine assessment of anthropometry, body composition and laboratory parameters to screen for signs of undernutrition.<sup>16</sup>

Despite these recommendations, there is a dearth of published data on the nutritional status of children with CP in Spain, and most of the available evidence focuses on specific regions in the country.<sup>17,18</sup> Thus, the main goal of our study was to achieve a broader perspective across different regions of the current situation of children with CP in Spain through the collection and analysis of data on their clinical and nutritional characteristics. In addition, we aimed to identify and analyse the comorbidities present in these patients and the nutritional support they had received.

## Methods

### Study design

We conducted a multicenter observational study including pediatric patients with CP managed in 10 Spanish hospitals. Eligible candidates were invited to participate when they visited the facility. In this same visit, researchers informed the parents about the study and, after obtaining informed consent, examined the patients in the same visit or scheduled a study visit for a later date. All the data required for the analyses were collected in a single visit.

This study (study number: 0114-N-19) adhered to the principles of the Declaration of Helsinki and was approved by the Malaga Provincial Research Ethics Committee of the Hospital Regional Universitario de Málaga.

### Participants

Children aged 4–14 years with a diagnosis of CP, regardless of GMFCS level classification, who provided written consent to participation (through their legal guardian) were included in the study. We obtained written informed from patients aged 13–14 years with normal cognition. We excluded Patients without an established diagnosis of CP.

We categorized patients according to the GMFCS,<sup>6</sup> which ranges from level I (least affected) to level V (most severely affected).

### Study variables

For each patient, we collected data on sociodemographic characteristics (age, sex), clinical characteristics (gestational age, multiple gestation, age at diagnosis, evolution time since diagnosis) and anthropometric measurements (birth weight, current weight, height, estimated height by tibia length, weight-to-height ratio, body mass index [BMI], upper arm circumference, triceps skinfold thickness). Anthropometric measurements were obtained through standardized techniques such as the use of measuring tape for perimeter and segmental height measures, skinfold calipers for subcutaneous folds and scales for body weight.

Malnutrition was evaluated by means of the Waterlow weight-for-height index and anthropometric values. The Waterlow classification was used to assess nutritional status in terms of wasting and the degree of stunting, considering the current weight of the patient in relation to the median weight of the reference population for the patient's height,<sup>19</sup> classifying patients into the following categories: obesity, normal weight and mild, moderate, and severe undernutrition. Malnutrition was also evaluated based on anthropometric measurement z scores, defining undernutrition as a z score of  $-2$  or lower.

We also collected data on variables related to schooling modality (special education, integration school, mainstream school), the number of meals and the type of nutrition provided at school (homemade food, homemade food with modified texture, gastrostomy), feeding method (oral, gastrostomy, mixed), need for supplementation with enteral formula, oral nutritional supplements (ONS) or both, and gastrointestinal comorbidities (dysphagia, constipation, gastroesophageal reflux). We used the Eating and Drinking Ability Classification System (EDACS) to assess the eating and drinking ability of children with CP.<sup>20</sup> Patients were classified into five levels (I to IV) according to the severity of their limitations in terms of safety and efficacy. The EDACS scale has been translated into Spanish and validated, and has been used previously in a Spanish cohort of children with CP.<sup>17</sup>

### Sample size calculation

Based on data published by Fernández-Jaén et al.,<sup>21</sup> for a confidence level ( $1-\alpha$ ) of 95% and a precision of 10% and estimating the prevalence of undernutrition in patients with CP at 45%, we calculated that the minimum sample size required was of 103 patients.

### Statistical analysis

We calculated measures of central tendency (mean, median) and dispersion (standard deviation [SD], interquartile range [IQR]) to summarize quantitative data. Categorical data were described in terms of absolute and relative frequencies. We have expressed anthropometric parameters as z scores using the growth data published by Sánchez González et al. as reference<sup>22</sup>. The arm area was calculated based on the upper arm circumference. We classified patients into two subgroups according to CP severity, as previously described: GMFCS I-III and GMFCS IV-V.<sup>23,24</sup> The fit of the variables to a normal distribution was assessed using the Shapiro–Wilk and Kolmogorov–Smirnov tests. For continuous variables, we used the Student *t* test or analysis of variance to analyze differences between subgroups if the data were normally distributed data or otherwise the nonparametric Mann–Whitney *U* or Kruskal–Wallis test. For qualitative variables, we used the  $\chi^2$  or Fisher exact test. We performed all the analyses on the available data without using any substitution technique for missing values. The statistical analysis was performed with the SAS software, version 9.4 (SAS Institute Inc, Cary, NC, USA). *P* values of less than 0.05 were considered statistically significant.

## Results

### Patient characteristics

A total of 112 patients with a mean age of 9.2 years (SD, 2.9) managed in 10 Spanish hospitals participated in the study (Table 1). According to the GMFCS, 33 patients were classified as GMFCS I-III and 79 patients as GMFCS IV-V.

### Anthropometric characteristics

In the total sample, the mean body weight and height of the patients at the time of the study visit were 25.7 kg (SD, 11.0) and 125.7 cm (SD, 17.0), respectively (Table 2).

Fig. 1(a–g) presents the mean z score values for each of the anthropometric measurements and the mean GMFCS level. Overall, patients with GMFCS IV-V had significantly lower mean z scores in every anthropometric parameter ( $P < .05$ ) except the height estimated based on the tibia length and the triceps skinfold thickness (Table 3).

In addition, the mean arm area in the total sample was 3072.44 mm<sup>2</sup> (SD, 1328.21), and was significantly higher in patients with GMFCS I-III (mean, 3688.01; SD:1541.26) compared to patients with GMFCS IV-V (mean, 2805.15; SD: 1134.77) ( $P = .0007$ ) (Fig. 1h).

### Nutritional status

The analysis of nutritional status showed that, based on the anthropometric characteristics (Table 3), approximately 26–52 % of the patients had undernutrition. In addition, based on body weight, BMI (z-score  $< -1$ ), height and upper arm circumference, there was a statistically significant higher proportion of undernourished patients in the GMFCS IV-V group compared to the GMFCS I-III group (Fig. 2, Table 4). When we considered undernutrition defined as a Waterlow index of less than 80, we found a higher proportion of patients with undernutrition in the GMFCS IV-V group ( $n = 13$ ; 38.2%) compared to the GMFCS I-III group ( $n = 4$ ; 14.8%) ( $P = .0502$ ).

### Schooling modality and nutritional support

Fifty-six (51.4%) patients attended special education schools, while 27 (24.8%) attended integration schools and 26 (23.9%) mainstream schools. A higher proportion of patients in the GMFCS IV-V group were enrolled in special education compared to patients in the GMFCS I-III group (68.4% vs. 12.1%;  $P < .0001$ ) (Supplementary Fig. S1a).

At school, 80 patients (73.4%) had at least one meal, while 30 (27.6%) had at least two meals, most frequently lunch ( $n = 51$ , 46.8%) and mid-morning snacks ( $n = 50$ , 45.9%), followed by breakfast ( $n = 12$ ; 11.0%).

Regarding the type of nutritional support, most patients received normal nutrition ( $n = 44$ ; 64.7%), while 11 (16.2%) received adapted nutrition and 13 (19.1%) fed through a gastrostomy tube (Supplementary Fig. S1b).

**Table 1** Patients and disease characteristics at the time of the study visit.

Characteristics	
Current age (years)	
Mean (SD)	9.2 (2.9)
Median (IQR)	9 (7–11)
Sex, No. (%)	
Male	58 (51.8)
Female	54 (48.2)
Gestational age (weeks)	
Mean (SD)	35.2 (5.4)
Median (IQR)	38 (30–40)
Gestational age group, No. (%)	
<28 weeks	17 (15.2)
28-<32 weeks	15 (13.4)
32-<37 weeks	18 (16.1)
≥37 weeks	62 (55.4)
Birth weight (g)	
Mean (SD)	2363.8 (1004.8)
Median (IQR)	2600 (1240–3150)
Multiple gestation, No. (%)	15 (13.4)
Age at diagnosis (years)	
Mean (SD)	1.6 (2.1)
Median (IQR)	1 (0–2.5)
Time elapsed from diagnosis (years)	
Mean (SD)	7.6 (3.2)
Median (IQR)	7.3 (5.3–10.1)
Etiology of cerebral palsy, No. (%)	
Prenatal <sup>a</sup>	24 (21.4)
Perinatal <sup>a</sup>	82 (73.2)
Postnatal	7 (6.3)
Motor type, No. (%)	
Spasticity	70 (62.5)
Dyskinesia/dystonia	3 (2.7)
Mixed (spasticity-dyskinesia)	39 (34.8)
Topography, No. (%)	
Monoparesis	1 (0.9)
Hemiparesis	16 (14.3)
Diparesis	13 (11.6)
Triparesis	6 (5.4)
Tetraparesis	76 (67.9)
GMFCS level, No. (%)	
I	10 (8.9)
II	16 (14.3)
III	7 (6.3)
IV	28 (25.0)
V	51 (45.5)
Waterlow weight-for-height index, No. (%)	
Obesity (>110)	12 (19.7)
Normal (90–110)	17 (27.9)
Mild undernutrition (80–90)	15 (24.6)
Moderate undernutrition (70–80)	12 (19.7)
Severe undernutrition (<70)	5 (8.2)

Abbreviations: GMFCS, Gross Motor Function Classification System; IQR, interquartile range; SD, standard deviation.

<sup>a</sup> For one patient, both causes were recorded.

**Table 2** Patients' anthropometric measurements at the study visit.

Anthropometric values	Mean (SD)	Median (IQR)
Body weight (kg)	25.7 (11.0)	22.6 (17.8–32.3)
z score	-1.35 (1.48)	-1.69 (-2.45 to -0.73)
Height (cm)	125.7 (17.0)	125 (114.0–139.0)
z score	-1.69 (1.77)	-1.94 (-2.65 to -0.16)
Estimated height by tibia length (cm)	124.9 (18.9)	122.4 (112.7–132.6)
Z-score (by tibia length)	-2.3 (2.6)	-2.35 (-4.11 to -1.10)
Z-score (by segments)	-1.59 (2.86)	-2.1 (-4.5, 0.5)
Body weight/height ratio	0.20 (0.06)	0.19 (0.16 to 0.23)
z score	-1.01 (2.04)	-1.27 (-2.38 to 0.12)
Body mass index (kg/m <sup>2</sup> )	15.8 (4.0)	14.9 (13.5–17.5)
z score	-0.79 (1.91)	-1.1 (-2.05 to 0.36)
Upper arm circumference (cm)	19.3 (3.9)	19 (16.5–21.0)
z score	-0.62 (1.78)	-0.70 (-1.79 to 0.5)
Triceps skinfold thickness (mm), median (IQR)	8.8 (5.5)	8 (5–11)
z score	-0.61 (1.88)	-0.62 (-1.80 to 0.4)

Abbreviations: IQR, interquartile range; SD, standard deviation.

**Table 3** Mean z score anthropometric measurements according to GMFCS group.

z score	Overall	I-II-III	IV-V	P
Body weight, mean (SD)	-1.35 (1.48)	-0.30 (1.31)	-1.76 (1.33)	<.0001
Height, mean (SD)	-1.69 (1.77)	-0.82 (1.20)	-2.41 (1.85)	0.0009
Weight/height ratio, mean (SD)	-1.01 (2.04)	-0.11 (1.58)	-1.40 (2.12)	0.0391
<b>Estimated height by segments, mean (SD)</b>	<b>-1.59 (2.86)</b>	<b>-0.30 (1.59)</b>	<b>-1.91 (3.06)</b>	<b>.4039</b>
Estimated height by tibia, mean (SD)	-2.3 (2.6)	-1.1 (0)	-2.4 (2.7)	0.1335
Body mass index, mean (SD)	-0.79 (1.91)	0.05 (1.59)	-1.16 (1.94)	.0019
Upper arm circumference, mean (SD)	-0.62 (1.78)	0.10 (1.53)	-0.94 (1.80)	.0155
Triceps skinfold thickness, mean (SD)	-0.61 (1.88)	-0.24 (1.77)	-0.78 (1.93)	.1255

Abbreviation: SD, standard deviation.

**Table 4** Undernutrition in study patients according to different anthropometric measurements and GMFCS level.

Anthropometric measurements	Undernutrition, No. (%)				P
	No		Yes		
	I-III	IV-V	I-III	IV-V	
Body weight (z score < -2)	26 (100.0)	31 (47.7)	0 (0.0)	34 (52.3)	<.0001
BMI (z score < -1)	19 (73.1)	23 (39.0)	7 (26.9)	36 (61.0)	.0048
BMI (z score < -2)	23 (88.5)	40 (67.8)	3 (11.5)	19 (32.2)	.0602
Height (z score < -2)	18 (78.3)	8 (28.6)	5 (21.7)	20 (71.4)	0.001
Upper arm circumference (z score < p <sub>10</sub> = -1.282)	20 (83.3)	29 (53.7)	4 (16.7)	25 (46.3)	.0211
Triceps skinfold thickness (z score < p <sub>10</sub> = -1.282)	16 (69.6)	28 (56.0)	7 (30.4)	22 (44.0)	.3127
Waterlow index (<90), No. (%)	16 (59.3)	13 (38.2)	11 (40.7)	21 (61.8)	.1264

Abbreviations: BMI, body mass index; GMFCS, Gross Motor Function Classification System; p<sub>10</sub>, 10th percentile.

### Feeding modality and nutritional support

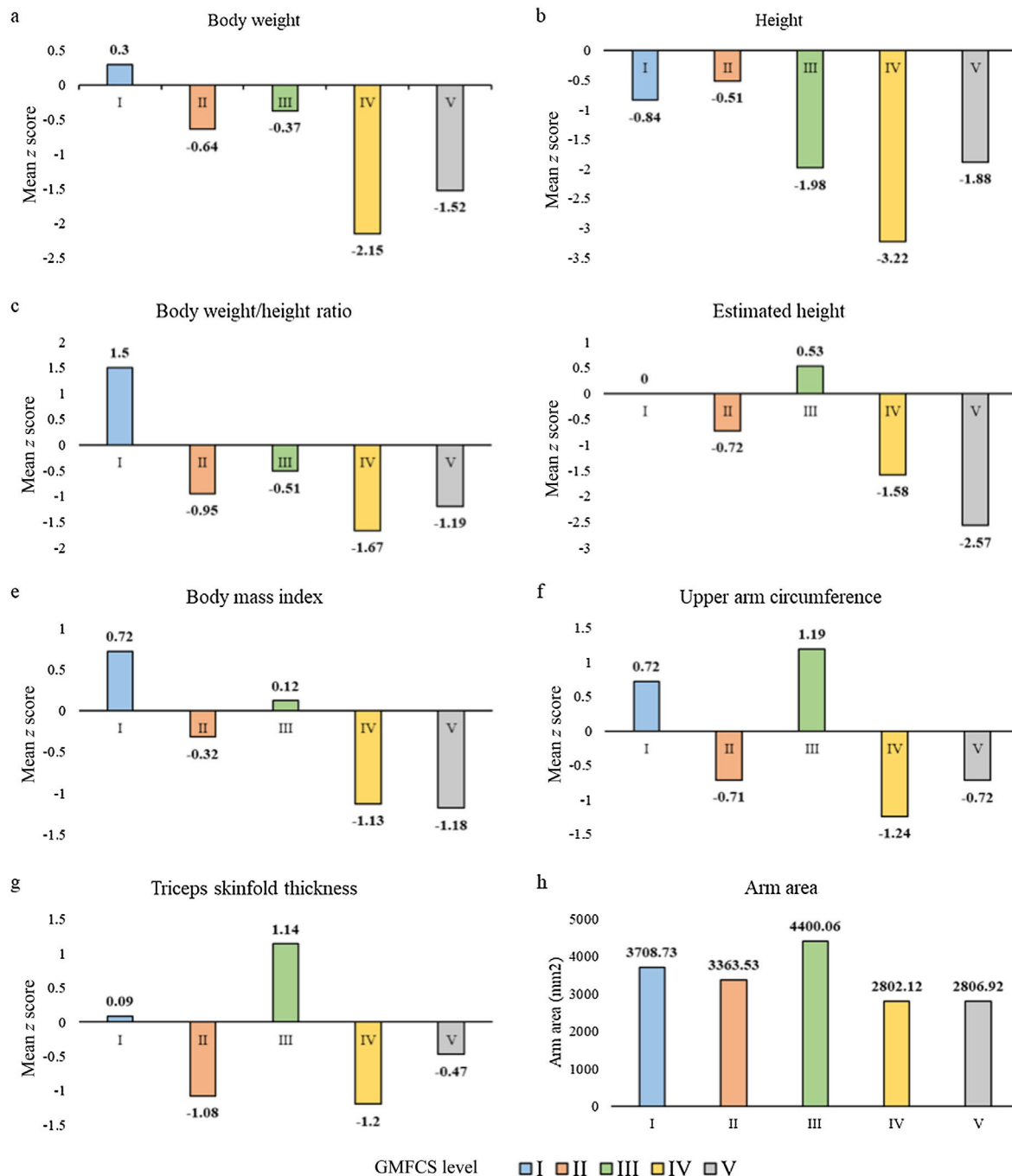
Most patients in the study (n = 87; 77.7%) fed orally, while 17 (15.2%) were fed via a gastrostomy tube and 8 (7.1%) received mixed feeding. Furthermore, 46 patients (41.1%) required nutritional support, and most of them (n = 42, 91.3%) were classified as GMFCS level IV-V (P < 0.001). In these patients, the most common route of administration of

nutritional support was oral for patients with GMFCS level IV (81.8%) and enteral for those with GMFCS V (45.2%) (Table 5).

### Gastrointestinal comorbidities

The analysis of comorbidities revealed that 54 patients (48.2%) had dysphagia, 50 (44.6%) constipation and 26 (23.2%) gastroesophageal reflux. In addition, 30 patients





**Figure 1** Mean z scores for anthropometric measurements (a-g) and the mean arm area (h) by GMFCS level. GMFCS, Gross Motor Function Classification System.

(26.8%) presented only one of these gastrointestinal comorbidities, while 26 (23.2%) had two and 16 (14.3%) had three concomitant gastrointestinal comorbidities.

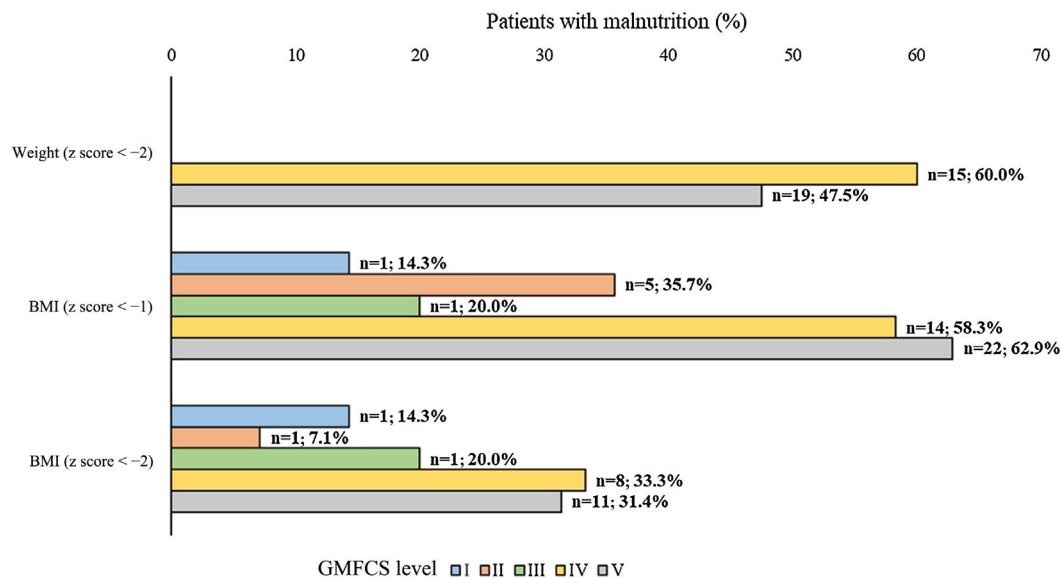
The analysis according to GMFCS classification revealed that a significantly higher proportion of patients in the GMFCS IV-V subgroup compared to the GMFCS I-III subgroup had dysphagia (62.0% vs. 15.2%;  $P = .0001$ ), constipation (51.9% vs. 27.3%;  $P = .0218$ ) and gastroesophageal reflux (31.6% vs. 3.0%;  $P = .0005$ ).

According to the EDACS score, half the patients ( $n = 51$ ; 50%) ate and drank with safety and efficiency limitations

(EDACS  $\geq$  III). We classified patients further according to both the EDACS and the GMFCS subgroups, finding that a significantly higher proportion of patients with more severe motor impairment based on the GMFCS had eating and drinking difficulties ( $P < .0001$ ) (Fig. 3).

## Discussion

Children with CP have impaired motor function, which can lead to feeding difficulties that in turn may result

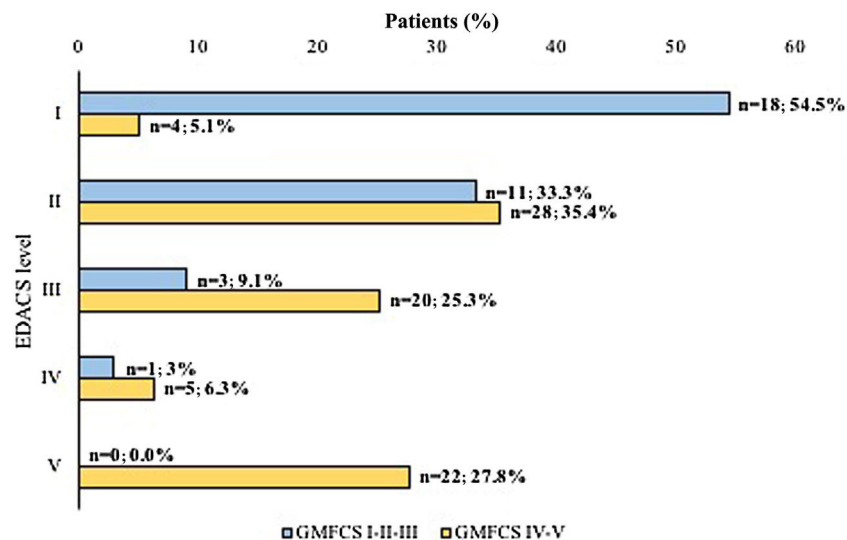


**Figure 2** Prevalence of undernutrition in the sample according to weight and BMI z scores and GMFCS level. BMI, body mass index.

**Table 5** Nutritional support according to GMFCS level.

	I	II	III	IV	V
No, No. (%)	10 (100.0)	14 (87.5)	5 (71.4)	17 (60.7)	20 (39.2)
Yes, No. (%)	0 (0.0)	2 (12.5)	2 (28.6)	11 (39.3)	31 (60.8)
Enteral	0 (0.0)	0 (0.0)	0 (0.0)	1 (9.1)	14 (45.2)
Oral	0 (0.0)	0 (0.0)	2 (100.0)	9 (81.8)	13 (41.9)
Mixed	0 (0.0)	2 (100.0)	0 (0.0)	1 (9.1)	4 (12.9)

Abbreviation: GMFCS, Gross Motor Function Classification System.



**Figure 3** Proportion of patients in each EDACS level by GMFCS level. EDACS, Eating and Drinking Ability Classification System; GMFCS, Gross Motor Function Classification System.

in a poor nutritional status and, therefore, the need of nutritional support. With this in mind, we aimed to study the clinical and nutritional status of children with CP in Spain.

To the best of our knowledge, this is the first multicenter study carried out in Spain describing different nutritional aspects in children with CP. The results of our study show that approximately 70% of children with CP managed in

Spanish pediatric neurology units who also received specialized gastroenterology and nutrition care exhibited severe motor impairment (GMFCS IV-V). Overall, these patients had significantly lower values for all anthropometric measurements compared to patients with GMFCS levels I-III, as previously described in the literature.<sup>24-27</sup>

Regarding their nutritional status, 28% of patients exhibited moderate or severe undernutrition based on the Waterlow index, while up to 52% had undernutrition based on other anthropometric measurements. The proportion of patients with undernutrition was significantly higher among those with GMFCS levels IV-V compared to those with GMFCS levels I-III. Previous studies in the field have yielded similar results. In a Spanish study in students with neurologic disabilities (58% children with CP), Costa et al found that approximately 64% had a GMFCS level IV-V and, overall, 56% had undernutrition according to the weight-for-age z score.<sup>18</sup> Although these results are similar to our own, their study was carried out in a single school and not all children had a diagnosis of CP, so the data may not be directly comparable. Similarly, in another study conducted in a single center in Spain, Martínez de Zabarte Fernández et al. reported that approximately 28% of children with CP had moderate-to-severe undernutrition according to the Waterlow weight index, with a greater prevalence (74%) in those with GMFCS levels IV-V.<sup>28</sup> Similar results have also been observed in other settings. For example, Ruiz Brunner et al. reported a prevalence of malnutrition of approximately 58% with moderate-to-severe undernutrition in 54% of patients, which was more frequent in children with GMFCS levels IV-V compared to children with GMFCS levels I-III.<sup>23</sup> In contrast, other authors have reported a lower prevalence of undernutrition (22%–34%).<sup>29,30</sup> In this context, it is worth noting that the ESPGHAN guidelines suggest that the identification of undernutrition in children should be based on anthropometric measurements.<sup>16</sup> However, Bell et al. observed that the pediatric Subjective Global Nutrition Assessment (SGNA) identified more children as potentially malnourished compared to anthropometric measurements such as BMI, height, and weight.<sup>31</sup> Although our results regarding undernutrition were similar to those reported by several other authors,<sup>18,23,31</sup> we might have underestimated the prevalence of undernutrition in our study.

In the total sample under study, 41% of the patients needed nutritional support, most of who had severe motor function impairment (GMFCS IV-V). The majority of these patients required oral nutritional support, although 45% of those with GMFCS level V required enteral nutritional support. The need for nutritional support in these patients should be evaluated individually considering their global nutritional status and energy requirements and the presence of gastrointestinal comorbidities and nutritional red flags.<sup>32,33</sup> Therefore, a multidisciplinary approach would be advisable.

In our cohort, almost half of the patients had gastrointestinal comorbidities, which based on the previous literature are frequent among children with CP.<sup>34</sup> The most common gastrointestinal comorbidity in our study was dysphagia, present in 48% of patients, with a higher prevalence in the GMFCS IV-V group, as previously reported.<sup>29</sup> Thus, half of all patients in our cohort exhibited eating and drinking limitations (EDACS  $\geq$  III), of who 92% were classified as

GMFCS IV-V. Similarly, in a recently published study, García Ron et al. assessed the nutritional status of 44 Spanish patients with CP and reported that 39% of patients had GMFCS levels IV-V and 43% were classified as EDACS  $\geq$  II.<sup>17</sup> Our results showed a higher proportion of patients in each of these groups (70% and 80%, respectively); however, it is worth noting that the study by García Ron et al. was carried out in a single center. Despite these differences, the data demonstrate that most Spanish children with CP have eating and drinking difficulties and some degree of undernutrition.

Overall, our results on the nutritional status of patients correlate with the fact that patients with a higher GMFCS level in our cohort were also classified in a higher EDACS level. In these patients, more severe motor impairment would result in eating and drinking dysfunction, leading to decreased nutrient intake and, consequently, to an undernourished status, explaining the increased need of nutritional support, which was enteral in a higher proportion of patients with GMFCS level V. Thus, clinicians should be aware of this situation and routinely assess children with CP for undernutrition red flags or comorbidities such as dysphagia. In addition, it could be useful to promote a multidisciplinary approach.

Our study has some limitations. We cannot rule out selection bias, as patients were not included in the study by random selection. Consequently, children with GMFCS levels IV-V may have been overrepresented in the sample. This could be due to the fact that they are more frequent patients at the specialist's office. However, more than 100 patients from 10 different centers participated in the study. Therefore, we believe that our results are representative of the situation of children with CP receiving gastroenterology and nutrition care in Spain and of routine clinical practice, reflecting the nutritional status of children with CP and the care they receive. In addition, follow-up data were not available as all the data were collected in a single visit. Notwithstanding, this study contributes relevant information about the current prevalence of undernutrition in this population based on the degree of motor impairment, as well as other results of interest concerning symptoms and comorbidities that could be useful to generate new hypotheses. Further follow-up studies would be useful to assess the evolution of nutritional status in patients receiving nutritional support.

In conclusion, our study highlights the prevalence of undernutrition and gastrointestinal comorbidities in the pediatric population with cerebral palsy in Spain, even in cases of mild impairment based on the GMFCS. Until now, data has been scarce or focused on specific geographic areas, whereas this work provides a broader perspective across different regions in the country. The results suggest a need for closer monitoring of nutritional status and gastrointestinal comorbidities, including dysphagia, by the specialists involved in their care, such as neurologists and gastroenterologists. This underscores the importance of allocating more healthcare resources to address these issues associated with CP.

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## Declaration of competing interest

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.anpedi.2025.503803>.

## References

- Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl.* 2007;109:8–14.
- Stavsky M, Mor O, Mastroli SA, Greenbaum S, Than NG, Erez O. Cerebral palsy-trends in epidemiology and recent development in prenatal mechanisms of disease, treatment, and prevention. *Front Pediatr.* 2017;5:21.
- Goldsmith S, McIntyre S, Blair E, Smithers-Sheedy H, Badawi N, Hansen M. Cerebral Palsy: Epidemiology. In: Eisenstat DD, Goldowitz D, Oberlander TF, Yager JY, editors. *Neurodevelopmental Pediatrics: Genetic and Environmental Influences.* Cham: Springer International Publishing; 2023. p. 479–95.
- Kim Y-M, Ashwal S. Diagnosis of Cerebral Palsy. In: Eisenstat DD, Goldowitz D, Oberlander TF, Yager JY, editors. *Neurodevelopmental Pediatrics: Genetic and Environmental Influences.* Cham: Springer International Publishing; 2023. p. 497–513.
- Bax M, Tydeman C, Flodmark O. Clinical and MRI correlates of cerebral palsy: the European Cerebral Palsy Study. *Jama.* 2006;296(13):1602–8.
- Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol.* 1997;39(4):214–23.
- Jesus AO, Stevenson RD. Optimizing nutrition and bone health in children with cerebral palsy. *Phys Med Rehabil Clin N Am.* 2020;31(1):25–37.
- Kuperminc MN, Stevenson RD. Growth and nutrition disorders in children with cerebral palsy. *Dev Disabil Res Rev.* 2008;14(2):137–46.
- da Silva DCG, de Sá Barreto da Cunha M, de Oliveira Santana A, Dos Santos Alves AM, Pereira Santos M. Malnutrition and nutritional deficiencies in children with cerebral palsy: a systematic review and meta-analysis. *Public Health.* 2022;205:192–201.
- Dutra E, Gomes A, Yamamoto R, Benedetti F, Martins J, Vargas C. Cerebral palsy: association between nutritional status and occurrence of oropharyngeal dysphagia. *Rev CEFAC.* 2019;21(5):e5519.
- Calis EA, Veugelers R, Sheppard JJ, Tibboel D, Evenhuis HM, Penning C. Dysphagia in children with severe generalized cerebral palsy and intellectual disability. *Dev Med Child Neurol.* 2008;50(8):625–30.
- Clavé P, Shaker R. Dysphagia: current reality and scope of the problem. *Nat Rev Gastroenterol Hepatol.* 2015;12(5):259–70.
- Arvedson JC. Feeding children with cerebral palsy and swallowing difficulties. *Eur J Clin Nutr.* 2013;67 Suppl 2:S9–12.
- Bell KL, Samson-Fang L. Nutritional management of children with cerebral palsy. *Eur J Clin Nutr.* 2013;67 Suppl 2:S13–6.
- Silva D, Cunha M, Santana AO, Alves A, Santos MP. Nutritional interventions in children and adolescents with cerebral palsy: systematic review. *Rev Paul Pediatr.* 2023;42:e2022107.
- Romano C, van Wynckel M, Hulst J, Broekaert I, Bronsky J, Dall'Oglio L, et al. European Society for Paediatric Gastroenterology, Hepatology and Nutrition Guidelines for the Evaluation and Treatment of Gastrointestinal and Nutritional Complications in Children With Neurological Impairment. *J Pediatr Gastroenterol Nutr.* 2017;65(2):242–64.
- García Ron A, González Toboso RM, Bote Gascón M, de Santos MT, Vecino R, Bodas Pinedo A. Nutritional status and prevalence of dysphagia in cerebral palsy: usefulness of the Eating and Drinking Ability Classification System scale and correlation with the degree of motor impairment according to the Gross Motor Function Classification System. *Neurologia (Engl Ed).* 2023;38(1):35–40.
- Costa A, Martin A, Arreola V, Riera SA, Pizarro A, Carol C, et al. Assessment of swallowing disorders, nutritional and hydration

- status, and oral hygiene in students with severe neurological disabilities including cerebral palsy. *Nutrients*. 2021;13(7).
19. Waterlow JC. Classification and definition of protein-calorie malnutrition. *Br Med J*. 1972;3(5826):566–9.
  20. Sellers D, Mandy A, Pennington L, Hankins M, Morris C. Development and reliability of a system to classify the eating and drinking ability of people with cerebral palsy. *Dev Med Child Neurol*. 2014;56(3):245–51.
  21. Fernández-Jaen A, Calleja-Pérez B. La parálisis cerebral desde la atención primaria. *Med Integral*. 2002;40:148–58.
  22. Sánchez González E, Carrascosa Lezcano A, Fernández García JM, Ferrández Longás A, López de Lara D, López-Siguero JP. [Spanish growth studies: the current situation, their effectiveness and recommendations for their use]. *An Pediatr (Barc)*. 2011;74(3):193.e1–16.
  23. Ruiz Brunner MLM, Cieri ME, Rodriguez Marco MP, Schroeder AS, Cuestas E. Nutritional status of children with cerebral palsy attending rehabilitation centers. *Dev Med Child Neurol*. 2020;62(12):1383–8.
  24. Ruiz Brunner MLM, Cieri ME, Butler C, Cuestas E. Development of equations and software for estimating weight in children with cerebral palsy. *Dev Med Child Neurol*. 2021;63(7):860–5.
  25. Tomoum HY, Badawy NB, Hassan NE, Alian KM. Anthropometry and body composition analysis in children with cerebral palsy. *Clin Nutr*. 2010;29(4):477–81.
  26. Jahan I, Muhit M, Hardianto D, Laryea F, Amponsah SK, Chhetri AB, et al. Epidemiology of malnutrition among children with cerebral palsy in low- and middle-income countries: findings from the global LMIC CP register. *Nutrients*. 2021;13(11).
  27. Naume MM, Jørgensen MH, Høi-Hansen CE, Nielsen MR, Born AP, Vissing J, et al. Low skeletal muscle mass and liver fibrosis in children with cerebral palsy. *Eur J Pediatr*. 2023;182(11):5047–55.
  28. Martínez de Zabarte Fernández JM, Ros Arnal I, Peña Segura JL, García Romero R, Rodríguez Martínez G. [Nutritional status of a population with moderate-severe cerebral palsy: beyond the weight]. *An Pediatr (Engl Ed)*. 2020;92(4):192–9.
  29. Leonard M, Dain E, Pelc K, Dan B, De Laet C. Nutritional status of neurologically impaired children: impact on comorbidity. *Arch Pediatr*. 2020;27(2):95–103.
  30. Caselli TB, Lomazi EA, Montenegro MAS, Bellomo-Brandão MA. Assessment of nutritional status of children and adolescents with Spastic Quadriplegic Cerebral Palsy. *Arq Gastroenterol*. 2017;54(3):201–5.
  31. Bell KL, Benfer KA, Ware RS, Patrao TA, Garvey JJ, Haddow R, et al. The pediatric subjective global nutrition assessment classifies more children with cerebral palsy as malnourished compared with anthropometry. *J Acad Nutr Diet*. 2020;120(11):1893–901.
  32. Scarpato E, Staiano A, Molteni M, Terrone G, Mazzocchi A, Agostoni C. Nutritional assessment and intervention in children with cerebral palsy: a practical approach. *Int J Food Sci Nutr*. 2017;68(6):763–70.
  33. Huysentruyt K, Geeraert F, Allemon H, Prinzie P, Roelants M, Ortibus E, et al. Nutritional red flags in children with cerebral palsy. *Clin Nutr*. 2020;39(2):548–53.
  34. Aydin K. A multicenter cross-sectional study to evaluate the clinical characteristics and nutritional status of children with cerebral palsy. *Clin Nutr ESPEN*. 2018;26:27–34.