

Nutritional status of children with cerebral palsy attending rehabilitation centers

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AIM To describe the nutritional status of children with cerebral palsy (CP) from rehabilitation and therapeutic centers in Argentina, and to analyze their risk of undernutrition based on their Gross Motor Function Classification System (GMFCS) level.

METHOD This was a cross-sectional study with data collected from 321 children (196 males, 125 females) with CP age 2 to 19 years (mean age 9y 3mo, SD 4y 5mo) from 17 rehabilitation and therapeutic centers in five Argentine provinces. Nutritional status was defined by height, weight, and body mass index for age z-scores using World Health Organization growth charts. Odds ratios were used to evaluate the association between GMFCS level and nutritional status.

RESULTS Of the children with CP studied, 52.4% were in GMFCS levels IV and V. Regarding the nutritional status, 41.7% were normal, 19.0% had moderate undernutrition, 33.9% severe undernutrition, 2.5% overweight, and 2.8% obese. When compared to those in GMFCS levels I to III, the odds of children in GMFCS levels IV and V having moderate undernutrition are four times greater and the odds of having severe undernutrition are 14 times greater.

INTERPRETATION There is a high prevalence of undernutrition associated with CP (GMFCS levels IV and V) among children in rehabilitation and therapeutic centers in Argentina. Risk of severe undernutrition increases with increased motor compromises.

In Argentina, there is no cerebral palsy (CP) register. In 2016, the last national survey reported over 19 000 children as having a motor disability registered with rehabilitation units within the health care system.¹ We know that approximately 30% of persons with disabilities in Argentina are not registered in the health care system, so this is likely to be a gross underestimate of the true figure.²

A child's nutritional status is highly correlated with their overall growth and development. In children with CP, nutritional assessment becomes challenging because the relationship between weight, height, growth, and body composition differs from that of typically developing children.^{3–5} Malnutrition is frequent in children with CP. Malnutrition includes a group of conditions that refers to deficiencies, excesses, or imbalances in a child's intake, energy, or nutrients. In all its forms, malnutrition includes undernutrition (wasting, stunting, and underweight), micronutrients-related malnutrition, and overweight, obesity, and diet-related non-communicable diseases.⁶

In children with CP, the aetiology of undernutrition is multifactorial and includes aspects such as hormonal

problems, motor abilities, and the consequences of the brain lesion,³ but poor nutrition causes an increase in the need for health care assistance and reduces the child's participation, thereby affecting their nutritional status.⁷ Undernutrition is responsible for a high number of childhood diseases worldwide, as its consequences increase the risk of death, micronutrient-related malnutrition, and the possibility of experiencing diseases.

Although the emerging nutritional problems among the general infant population in Argentina are overweight and obesity,⁸ the nutritional problems in Argentine children with CP are unknown. To our knowledge, there are no studies demonstrating the prevalence of malnutrition in children with CP in Argentina. Therefore, the two aims of this study were: (1) to describe the nutritional status of children with CP and (2) to analyze the risk of undernutrition based on their Gross Motor Function Classification System (GMFCS) level.

METHOD

This was a cross-sectional study. Participants were children and adolescents with a diagnosis of CP from 2 to 19 years

old. Diagnoses of CP were made by pediatric neurologists according to the characteristics set forth in the international definition of CP,^{9,10} and the International Classification of Diseases, 10th Revision. Magnetic resonance imaging was performed in some cases. Those with genetic or metabolic syndromes that could have or had affected their growth (e.g. Angelman syndrome, chromosomal variation, etc.) were excluded as were children for whom reliable height measures could not be obtained or estimated. Data were collected from consecutive children who attended 17 rehabilitation centers and therapeutic centers in five Argentine provinces (Córdoba, Jujuy, the Autonomous City of Buenos Aires, Santiago del Estero, and Catamarca) from July 2016 to December 2018. These institutions were rehabilitation and therapeutic educational centers specializing in motor rehabilitation.

The project was approved by the Ethical Evaluation Board of Health Research (COEIS) of the province of Córdoba (REPIS N° 3262/3236). Written informed consent was obtained from all participants and their parents or legal guardians. The study was registered in ClinicalTrials.gov (NCT03303755).

Anthropometric measurements

Anthropometric measurements of weight and height were collected using direct methods while the children were wearing light clothes and no shoes. Guidelines for anthropometric assessment for children with and without disabilities were followed by health professionals.^{11,12} The same standardized anthropometric protocol was followed at all centers. All measurements were taken twice by two health professionals, and the average measure was used for analysis. Inter- and intrarater reliability testing was performed with kappa agreement.

Weight was obtained in kilograms to the nearest 100g using a wheelchair scale or a digital scale, depending on the child's abilities. For those children who were able to stand, height or length was measured in cm with a portable stadiometer (SECA model 213; SECA, Hamburg, Germany). When direct height could not be obtained (e.g. children in GMFCS level V), it was estimated using published equations for children with CP up to 12 years using knee height.¹³ Children older than 12 years whose height could not be estimated were excluded.

Nutritional assessment

Nutritional status was defined based on the anthropometric measures using international references of typically developing children in accordance with international guidelines.^{14,15} All measurements were converted to z-scores based on age and sex references from the World Health Organization¹⁶ using World Health Organization Anthro Plus V1.0.4 software.

Undernutrition was defined according to the World Health Organization including wasting (low weight-for-height), stunting (low height-for-age), and underweight (low weight-for-age), and it was classified as moderate or severe undernutrition according to the z-scores.⁶

What this paper adds

- High prevalence of moderate and severe undernutrition among children with cerebral palsy was found.
- Children attending Argentine rehabilitation and therapeutic centers are most commonly in levels IV and V of the Gross Motor Function Classification System (GMFCS).
- Children classified in GMFCS levels IV and V demonstrate more risk of severe undernutrition.

The cut-off points to assess the nutritional anthropometric status were defined as follows. 'Normal' was considered when weight for age and body mass index (BMI) for age had a z-score between -1.99 and 1.99, and height for age was greater than -2.0. Moderate undernutrition was established when z-scores of weight for age, height for age, or BMI for age were between -2 and -2.99, and no z-score for weight for age, height for age, or BMI for age was below -3. Severe undernutrition was considered when z-scores of weight for age, height for age, or BMI for age were below -3. When a child did not meet the criteria for any of the preceding categories, overweight was defined if BMI for age z-scores were between 2 and 3, and obesity when the BMI for age z-scores were greater than 3.

Oral and non-oral feeding data were collected. Non-oral feeding included children who were fed completely or partially with a feeding tube.

Gross motor function level

The GMFCS was developed in 1997 for children and adolescents with CP and establishes five levels of motor function. In this study, GMFCS levels were classified by physicians and physiotherapists according to the expanded and revised definition.¹⁷ For analytical purposes, GMFCS levels were collapsed into two categories: (1) levels I to III and (2) levels IV and V.

Statistical analysis

The normality of the continuous data was tested using the Kolmogorov-Smirnov test. Normal data were described in means and standard deviations, while those of non-normal distribution were described in medians with their interquartile ranges. The discrete data were expressed in percentages with 95% confidence intervals (CIs). Simultaneous CIs for multinomial proportions were calculated with the R Studio software version 1.1.453 (R Foundation for Statistical Computing, Vienna, Austria) using the package multinomial CIs.¹⁸ Odds ratios with 95% CIs were calculated to measure the magnitude of association between the two levels of gross motor functioning (GMFCS levels I-III vs levels IV and V) with four nutritional status groups (normal, moderate undernutrition, severe undernutrition, overweight and obesity) using the Mantel-Haentzel test to probe statistical differences between the groups. The statistical significance was predefined at $p < 0.05$. The data were analyzed using STATA 13.0 (Stata Corp LP, College Station, TX, USA).

RESULTS

A total of 479 children were asked to participate in the study. Forty-six (10.6%) children were excluded because of: (1) unavailability at the time of data collection, (2) the presence of potential growth-impairing neurogenetic syndromes, or (3) lack of consent. In 144 (33.3%) children, height could not be measured in standing or supine position, only knee height could be measured. Of that group, the height of 78 children was estimated using the Stevenson equation¹³ as they were under 12 years of age, and the other 66 children were excluded as no height estimating equation was available for CP (Fig. S1, online supporting information).

The final sample was made up of 321 children with CP (196 [61.1%] males, 125 [38.9%] females). The mean age of the participants was 9 years 3 months, SD 4 years 5 months (range 2–19y). The characteristics of the sample regarding the diagnostic type are presented in Table 1.

Nutritional status according to GMFCS level is presented in Table 2. Undernutrition had a very high prevalence overall, with 52.9% of the participants classified as undernourished. The prevalence of undernourishment increased as GMFCS level increased.

The distribution of the BMI for age was also analyzed, comparing the groups of children in GMFCS levels I to III and those in GMFCS levels IV and V, in relation to the World Health Organization reference population. Figure 1 shows that the nutritional status in the participants was more compromised as the severity of CP

Table 1: Characteristics of children with cerebral palsy from rehabilitation and therapeutic centers in Argentina

Characteristics	n	% [95% CI]
Total	321	100
Classification by GMFCS level		
I	56	17.4 [12.1–23.3]
II	49	15.3 [10.0–21.1]
III	48	15.0 [9.7–20.8]
IV	50	15.6 [10.3–21.4]
V	118	36.8 [31.5–42.6]
Level of severity		
Mild (GMFCS level I and II)	105	32.7 [27.1–38.5]
Moderate (GMFCS level III)	48	15.0 [9.3–20.8]
Severe (GMFCS level IV and V)	168	52.3 [46.7–58.2]
Classification by topography		
Quadriplegia (bilateral)	142	44.2 [38.6–50.1]
Diplegia (bilateral)	63	19.6 [14.0–25.5]
Hemiplegia (unilateral)	44	13.7 [8.1–19.5]
Not specified	72	22.4 [16.8–28.3]
Classification by motor type		
Spasticity	123	38.3 [32.7–44.3]
Ataxia	17	5.3 [0.0–11.2]
Dyskinesia	22	6.9 [1.2–12.8]
Mixed	32	10.0 [4.4–15.9]
Not specified	127	39.6 [34.0–45.5]
Feeding		
Oral feeding	292	91.0 [88.2–94.0]
Non-oral feeding ^a	29	9.0 [6.2–12.1]

^aOf the 29 children with non-oral feeding, 25 were only tube-fed and four were both tube-fed and orally fed. CI, confidence interval; GMFCS, Gross Motor Function Classification System.

Table 2: Nutritional status according to type of malnutrition in children with cerebral palsy, according to World Health Organization nutritional standards¹⁶

	GMFCS level I	GMFCS level II	GMFCS level III	GMFCS level IV	GMFCS level V	Total
Nutritional assessment	n=56	n=49	n=48	n=50	n=118	n=321
Normal, n (%) [95% CI]	40 (71.4) [60.7–82.1]	37 (75.5) [65.3–87.2]	22 (44.9) [33.3–62.1]	13 (26.0) [12.0–40.3]	22 (18.6) [10.2–27.8]	134 (41.7) [36.1–47.8]
Moderate undernutrition, n (%) [95% CI]	5 (8.9) [0.0–19.6]	7 (14.3) [4.1–26.0]	13 (26.5) [14.6–43.3]	13 (26.0) [12.0–40.3]	23 (19.5) [11.0–28.7]	61 (19.0) [13.4–25.1]
Severe undernutrition, n (%) [95% CI]	5 (8.9) [0.0–19.6]	2 (4.1) [0.0–15.8]	11 (22.4) [10.4–39.2]	21 (42.0) [28.0–56.3]	70 (59.3) [50.8–68.5]	109 (34.0) [28.3–40.0]
Overweight, n (%) [95% CI]	5 (8.9) [0.0–19.6]	1 (2.0) [0.0–13.7]	0 (0.0) [0.0–16.2]	1 (2.0) [0.0–16.3]	1 (0.8) [0.0–10.0]	8 (2.5) [0.0–8.6]
Obesity, n (%) [95% CI]	1 (1.8) [0.0–12.5]	2 (4.1) [0.0–15.8]	2 (4.1) [0.0–20.4]	2 (4.0) [0.0–18.3]	2 (1.7) [0.0–10.9]	9 (2.8) [0.0–8.9]

GMFCS, Gross Motor Function Classification System; CI, confidence interval.

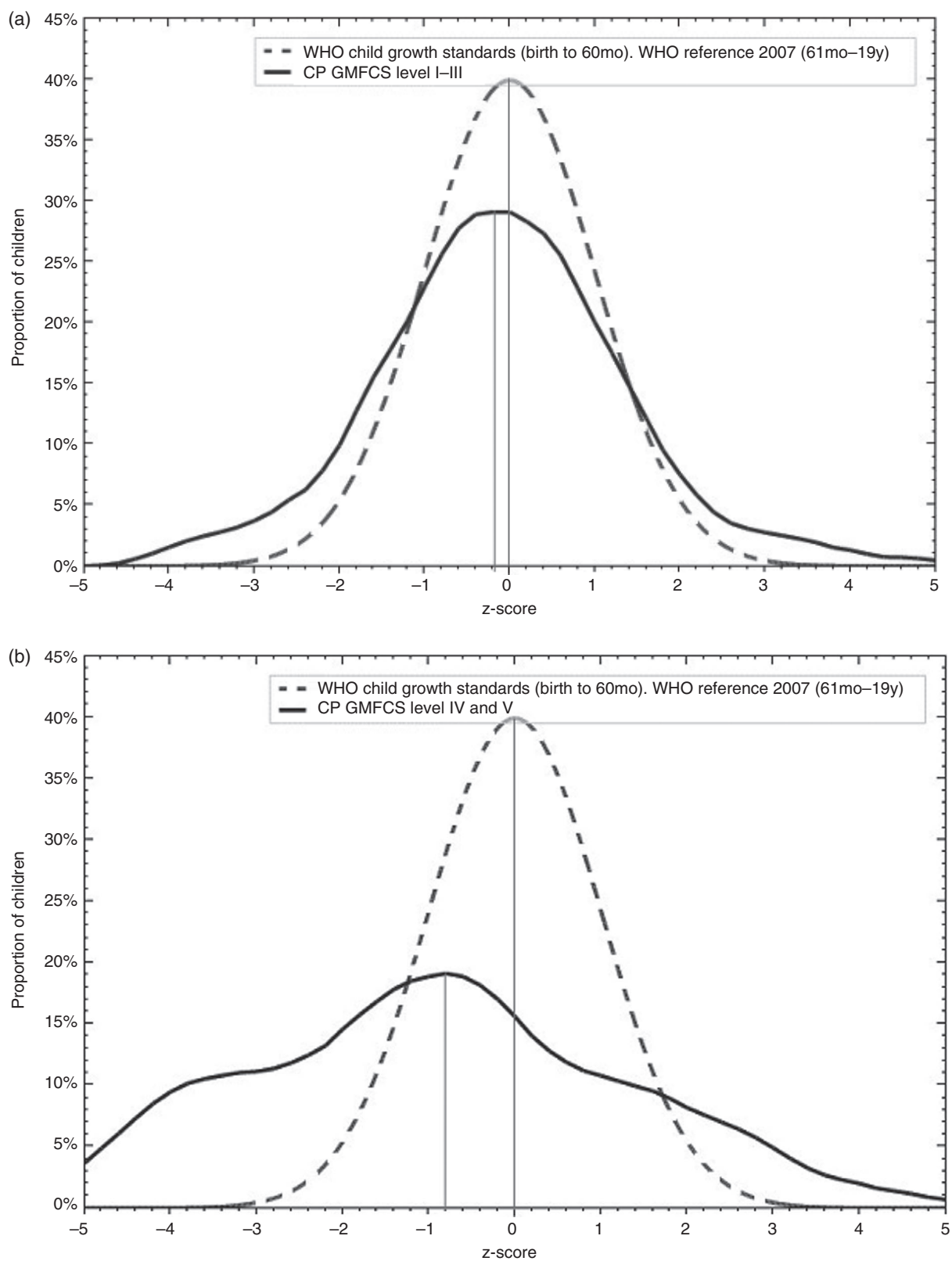


Figure 1: Comparison of children with cerebral palsy (CP) and the World Health Organization (WHO) population standards¹⁶ of body mass index (BMI) for age according to Gross Motor Function Classification System (GMFCS) level ($n=321$). The WHO curve (dotted line) is a standard normal distribution. Grey lines refer to the mean of each distribution. (a) Distribution of BMI for age in children in GMFCS levels I-III ($n=153$). (b) Distribution of BMI for age in children in GMFCS levels IV and V ($n=168$).

Table 3: Odds of moderate undernutrition, severe undernutrition, and overweight or obesity comparing children in GMFCS levels IV and V to children in GMFCS levels I to III (*n*=321)

Anthropometric nutritional status	<i>n</i>	GMFCS level IV and V <i>n</i> (%) [95% CI]	GMFCS level I-III <i>n</i> (%) [95% CI]	OR	95% CI	<i>p</i>
Normal	134	35 (26.2) [19.4–34.2]	99 (73.8) [65.8–80.6]	Section references		<0.001
Moderate undernutrition	61	36 (59.0) [46.5–70.5]	25 (41.0) [29.5–53.5]	4.1	2.1–7.7	
Severe undernutrition	109	91 (83.5) [75.3–89.4]	18 (16.5) [10.6–24.7]	14.3	7.6–27.0	
Overweight or obesity	17	6 (35.3) [17.1–58.8]	11 (64.7) [41.2–82.8]	1.5	0.5–4.5	

Normal: weight for age and body mass index (BMI) for age had a z-score between -1.99 and 1.99 , and height for age greater than -2.0 . Moderate undernutrition: z-scores of weight for age, height for age, or BMI for age were between -2 and -2.99 . Severe undernutrition: z-scores of weight for age, height for age, or BMI for age were below -3 . Overweight and obesity: BMI for age z-scores were greater than 2 . GMFCS, Gross Motor Function Classification System; OR, odds ratio; CI, confidence interval.

increased, which means that the growth pattern was markedly different from normal.

There was a significant association between the level of motor function and nutritional status in children with CP. The odds of being moderately undernourished were four times higher, and of being severely undernourished 14 times higher, for children in GMFCS levels IV and V compared to those in GMFCS levels I to III (Table 3).

DISCUSSION

To our knowledge, this is the first study to describe the nutritional status of children and adolescents with CP who attend rehabilitation and therapeutic centers in Argentina. According to our results, there is a high risk of Argentine children with CP attending rehabilitation and therapeutic centers presenting severe and moderate undernutrition when the motor disability is severely compromised (GMFCS levels IV and V). We found a significant relationship between GMFCS levels IV and V and undernutrition, compared to children in GMFCS levels I to III. Undernutrition is associated with the severity of motor impairments represented by GMFCS level: as the motor disability increases, the risk of undernutrition also increases.

It was observed that half of the children with CP from Argentine rehabilitation and therapeutic centers were in GMFCS levels IV and V, similar to previous studies in Latin America.¹⁹ These findings are different from studies in developed countries, such as the USA and Australia, where the prevalence of GMFCS levels IV and V is close to 20% in children with CP.^{4,20,21} However, the high prevalence of GMFCS levels IV and V cases found in our sample of rehabilitation centers might not be representative of the whole CP population in Argentina. A local CP register would help to analyze the severity of motor function in children with CP, but this is not yet available.

Our findings support previous research in which the level of CP severity is associated with a compromise in growth attainment; as severity increases, the health compromise becomes greater.^{4,22} This affects growth, leading children with CP to be lighter, shorter, and thinner than typically developing children.^{7,23} In children with CP attending rehabilitation and therapeutic centers in Argentina there is a predominance of undernutrition.

Undernutrition affected more than half of the children studied, showing similarities with results from other studies in Latin America,^{19,24,25} Africa,^{26,27} and Asia.²⁸ The prevalence of nutritional problems differs from those reported in developed countries, where there is a greater proportion of children who achieve a normal nutritional status and where the latest studies show an increase in overweight and obesity.^{5,29,30}

Because of the differences in growth between children with CP and typically developing children, specific growth charts that describe growth in children with CP have been developed in the USA.⁴ A recent study in the UK showed that the BMI of children with CP from the UK fitted well with the US CP charts, but presented a poor fit for height and weight in GMFCS levels IV and V.³¹ There are still many unanswered questions about growth in children with CP comparing growth patterns between different countries. Further studies will need to be undertaken.

Although more than half of the sample presented undernutrition, only 9% of the children with CP had tube feeding. The high prevalence of undernutrition in the sample of children with CP could be related to difficulties in feeding as their motor disability increases. However, it would be necessary to extend the study to all of the variables, such as growth hormone deficit, calorie consumption, nutrient deficits, and difficulty in food ingestion, among others linked to the nutritional status, in order to further analyze the risk factors.

There are some limitations to this study. Selection bias may have occurred because many children over 12 years old had to be excluded because of the impossibility of measuring or estimating their height. Although knee height was used to estimate height using Stevenson equations,¹³ these equations allow the estimation of height only in children under 12 years, which raises the need to elaborate validated predictive equations for these subgroups. The fact that the children were recruited from centers specializing in motor disabilities might be the reason for more children in GMFCS levels IV and V being included in the sample. Therefore, data presented here might only be valid for children with CP who attend rehabilitation centers in Argentina. The main strength of this study is that it is the first study to present results of nutritional status in Argentina. The study analyzed data collected prospectively in

several provinces of the country and presents a large and adequately representative sample, which allows for appropriate inferences because of its statistical power. In addition, it is the first study to highlight the nutritional problems of the children with CP in rehabilitation and therapeutic centers in Argentina, making it possible to plan future policies for their potential improvement.

CONCLUSION

In conclusion, undernutrition affects a large number of children with CP in rehabilitation and therapeutic centers in Argentina. The risk of undernutrition, moderate and severe, increases with GMFCS level and is of great importance in children with severe motor impairment (GMFCS

levels IV and V). It is necessary to continue studying growth and nutritional risk factors in children with CP in Argentina, to prevent and treat undernutrition.

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SUPPORTING INFORMATION

The following additional material may be found online:

Figure S1: Participants flow chart.

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