



Original article

A multicenter cross-sectional study to evaluate the clinical characteristics and nutritional status of children with cerebral palsy[☆]Kursad Aydin^{*}, on behalf of Turkish Cerebral Palsy Study Group¹

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SUMMARY

Background & aims: This study was designed to assess clinical characteristics and nutritional status of pediatric outpatients with cerebral palsy (CP) and to determine prevalence of malnutrition based on physicians' clinical judgment and on anthropometric data in relation to percentile reference values.

Methods: A total of 1108 pediatric neurology outpatients (mean $\pm$ SEM age: 7.2 ± 0.1 years, 59.3% were males) diagnosed with CP were included in this cross-sectional, non-interventional multicenter single-visit study conducted between October 2015 and July 2016 at 20 centers across Turkey. Data on patient and CP characteristics, concomitant nonneuromotor impairments and gastrointestinal disorders as well as anthropometrics, outcome of nutritional status assessment (via physicians' clinical judgment and Gomez classification and Waterlow classification of anthropometric data) and physician's view on nutritional care in CP patients were collected at a single visit.

Results: The most common CP etiology was asphyxia (62.5%). The most common clinical category was spastic CP (87.5%) with quadriplegic (54.0%) topography and level V gross motor dysfunction (45.4%) in most of patients. The prevalence of malnutrition was considered to be 57.2% based on physicians' clinical judgment, while shown to be 94.3% (3rd degree in 86.7%) according to Gomez classification of Neyzi weight for age (WFA) percentiles and to be 91.3% (severe in 88.3%) according to Waterlow classification of Neyzi height for age (HFA) percentiles.

Conclusions: In conclusion, our findings revealed high prevalence of malnutrition, while also emphasize the likelihood of overestimation of malnutrition in children with CP when anthropometric assessment was based on use of growth charts for general pediatric population. This large-scale survey provided valuable data regarding nutritional assessment practice and malnutrition prevalence among children with CP in Turkey, which may be utilized for future proactive strategies in the prevention and treatment of malnutrition in this population.

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1. Introduction

Cerebral palsy (CP) is the most prevalent cause of motor disability in children [1,2] with a global incidence of approximately 2–2.5 per 1000 live births [2,3] and incidence of 4.4 per 1000 live births in Turkey [4].

CP is a syndrome of motor impairment comprising a wide spectrum of childhood movement and posture disorders and often accompanied by disturbances of sensory, cognitive, perceptive, behavioral or epileptic disorders [3,5,6].

Primary neurological insult influences not only physical and mental capacities but also enteric neural pathways leading to dysphagia, vomiting, swallowing deficits, gastroesophageal reflux, aspiration and constipation, compromising the adequate nutrient intake in children with CP [7–10].

Accordingly, children with cerebral palsy are considered to be at an increased risk of malnutrition [7,11,12], and those with severe and longer term gross motor impairment and oropharyngeal dysfunction are considered to have a higher prevalence of malnutrition [10,13,14]. Moreover, poor nutritional status itself has been

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associated with further risk of adverse social, motor, cognitive and health outcomes including respiratory and cardiac dysfunction and mortality [9,13–16].

Assessment of nutritional status and early identification and management of malnutrition via multidisciplinary approach is therefore considered essential for the optimal care in children with CP [10,11,13,17,18].

However, alongside a lack of a gold standard validated pediatric nutrition screening tool in routine clinical practice [19], nutritional assessment in CP is further complicated by the challenges inherent in anthropometry in these children [18,20]. Thus, there is ongoing effort to improve nutritional rehabilitation practice among children with CP by using the most appropriate assessment tools to obtain a more accurate anthropometric profile and more realistic nutritional goals [13,18,20,21].

This study was designed to assess clinical characteristics and nutritional status of pediatric outpatients with CP and to determine prevalence of malnutrition based on physicians' clinical judgment and on anthropometric data in relation to percentile reference values.

2. Materials and methods

2.1. Study population

A total of 1108 pediatric neurology outpatients diagnosed with CP were included in this cross-sectional, non-interventional multi-center single-visit study conducted between October 2015 and July 2016 at 20 centers directed by members of Turkish Pediatric Neurology Society across Turkey. Male or female pediatric neurology outpatients diagnosed with CP aged ≥ 1 and < 19 years were included in the study. Genetic disorders, cardiopathies, hypothyroidism or any CP-unrelated chronic diseases, CP of postnatal origin (i.e. traumatic brain injury, near drowning, motor vehicle accident, brain tumor, and/or other acquired injuries) and other concomitant diagnoses (i.e. autism, Down syndrome, degenerative disorders, renal disease, or any other significant diagnosis according to the investigator) were the exclusion criteria. Of 1115 patients initially enrolled, 1108 patients were found eligible to participate in this study since 7 patients were excluded due to protocol violation (not meeting the inclusion criteria for age) detected after enrollment.

Written informed consent/assent was obtained from children and/or children's parents or legal guardian following a detailed explanation of the objectives and protocol. The study was conducted in accordance with the ethical principles stated in the "Declaration of Helsinki" and approved by the institutional ethics committees.

2.2. Data collection

Data on patient demographics (age, gender), birth characteristics (delivery method, gestational age, anthropometrics at birth), CP characteristics [age at CP diagnosis, etiology and type of CP, affected body parts, GMFCS (Gross Motor Function Classification System) level, presence of sibling with CP, CT/MRI findings], concomitant nonneuromotor impairments and gastrointestinal disorders as well as anthropometrics and outcome of nutritional status assessment (via Gomez classification, Waterlow classification and based on physicians' clinical judgment) and physician's view on nutritional care in CP were collected at a single visit.

2.3. Outcome measures

Outcome measures included patient profile and CP characteristics, anthropometric measurements, prevalence of malnutrition (according to physicians' clinical judgment and anthropometric

data in percentiles using Gomez classification and Waterlow classification), and physicians' view on nutritional care in CP.

2.4. CP classification

CP was clinically categorized into spastic, dyskinetic or extrapyramidal, cerebellar or ataxic, hypotonic, and mixed, on the basis of the predominant motor impairment [22].

GMFCS was used to classify severity of motor impairment into five subgroups including level I (walks without limitations), level II (walks with limitations), level III (walks using a hand-held mobility device), level IV (self-mobility with limitations, may use powered mobility) and level V (transported in a manual wheelchair) according to published criteria [23].

2.5. Anthropometrics

Anthropometric measurements included body weight (kg), height (cm), body mass index (BMI; kg/m^2), head circumference (cm), triceps skinfold thickness (TSFT) and mid-upper arm circumference along with estimation of mean z-scores and percentiles for weight-for-age (WFA), height-for-age (HFA), head circumference-for-age (HCFA) and weight for height (WFH). Body weight was measured using a digital baby weight scale (10 g precision) in children aged ≤ 2 years, while with adult electronic scale (100 g precision) in children aged > 2 years. Height measurement was performed using a 1-m length measuring tape (0.1 cm precision) in children aged ≤ 2 years and with a wall mounted stature meter (0.2 cm precision) in children aged > 2 years. MUAC was measured from the left upper arm flexed slightly at the elbow, at half distance between the acromion and the olecranon using a plastic measuring tape. TSFT was measured from the left arm, and at half distance between the acromion and the olecranon, using a skin fold caliper. TSFT and MUAC percentiles could only be analyzed in those aged 1–8 years because lack of Neyzi reference for these measures and availability of growth reference data (WHO) for these measures up to age of 8 years.

2.6. Nutritional status assessment

Nutritional status assessment was based on physicians' clinical judgment as well as anthropometric data including Gomez classification of WFA percentiles and Waterlow classification of WFH and HFA percentiles using WHO and/or Neyzi standard growth charts.

2.7. Gomez classification

The Gomez classification uses the percent-of-median, which is a convenient measure if the reference population distribution has not been normalized. On the basis of availability of WHO or Neyzi percentiles which are normalized databases, Gomez and Waterlow cut points were applied to the WHO (or Neyzi) percentiles in the present study. Gomez classification of nutritional status was based on WFA percentiles and categorized as normal nutritional status (percentile 91–100), 1st degree malnutrition (percentile 76–90), 2nd degree malnutrition (percentile 61–75) and 3rd degree malnutrition (percentile ≤ 60) [24]. While the classification was created using both WHO and Neyzi standard growth charts, it should be noted that WHO WFA growth chart involves data only up to 10 years of age whereas the Neyzi WFA growth charts continues to 18 years of age, therefore the Gomez classification for WHO could only be created for children up to 10 years of age.

Table 1
Baseline patient and disease characteristics.

Demographic characteristics		
Gender, n (%)		
Male		657 (59.3)
Female		451 (40.7)
Age at enrollment (year), mean $\pm$ SEM		
Age groups, n (%)		
≥ 1 y ≤ 4 y		341 (30.8)
>4 y ≤ 8 y		335 (30.2)
>8 y ≤ 12 y		239 (21.6)
>12 y ≤ 16 y		154 (13.9)
>16 y		39 (3.5)
Birth characteristics		
Birth method, n (%)		
Normal spontaneous vaginal delivery		520 (46.9)
Cesarean section		586 (52.9)
Gestational age (weeks, n = 1088), mean $\pm$ SEM		
Birth weight (g, n = 1038)		
mean $\pm$ SEM		2450.38 $\pm$ 30.11
weight for age		–2.11 $\pm$ 0.07
z-score		
weight for age percentile		21.70 $\pm$ 0.92
Birth height (cm, n = 279)		
mean $\pm$ SEM		46.97 $\pm$ 0.31
height for age		–1.28 $\pm$ 0.14
z-score		
height for age percentile		35.56 $\pm$ 1.86
Birth head circumference (cm, n = 174)		
mean $\pm$ SEM		33.57 $\pm$ 0.33
HC for age z-score		–0.83 $\pm$ 0.24
HC for age percentile		45.84 $\pm$ 3.03
Parental consanguinity, n (%)		
Multiple birth, n (%)		
		286 (25.8)
		105 (9.5)
CP characteristics		
Age at CP diagnosis, n = 1052, mean $\pm$ SEM (month)		
<1 y		30.6 $\pm$ 0.9
≥ 1 y ≤ 4 y		431 (38.9)
>4 y ≤ 8 y		446 (40.3)
>8 y ≤ 12 y		129 (11.6)
>12 y ≤ 16 y		42 (3.8)
>16 y		4 (0.4)
		0 (0.0)
CP etiology, n (%)		
Asphyxia		692 (62.5)
Prematurity		493 (44.5)
Low birth weight		505 (45.6)
Hyperbilirubinemia		104 (9.4)
Cerebral development anomaly		93 (8.4)
Intrauterine infection		28 (2.5)
Neonatal neurological problems		94 (8.5)
Other		106 (9.6)
Total number of CP etiologies		
Single		451 (40.7)
Multiple		657 (59.3)
Type of CP, n (%)		
Spastic		969 (87.5)
Dyskinetic/dystonia		67 (6.0)
Dyskinetic/athetosis		9 (0.8)
Dyskinetic/N/A		1 (0.1)
Ataxic-hypotonic		45 (4.1)
Mixed		15 (1.4)
Affected parts of body, n (%)		
Quadriplegic		598 (54.0)
Diplegic		346 (31.2)
Hemiplegic		152 (13.7)
Monoplegic		11 (1.0)
GMF classification, n (%)		
Level 1		114 (10.3)
Level 2		255 (23.0)
Level 3		112 (10.1)
Level 4		124 (11.2)
Level 5		503 (45.4)
Siblings with CP, n (%)		
CT/MRI Findings, n(%)		
Periventricular leukomalacia		592 (53.4)
Pyramidal/putamen/thalamic		129 (11.6)
Cerebral developmental anomaly		98 (8.8)
Cerebral atrophy		221 (19.9)
Calcification		8 (0.7)

Table 1 (continued)

Cerebral ischemia	57 (5.1)
Other	211 (19.0)
Concomitant disorders, n (%)	
Epilepsy	613 (55.3)
Strabismus	58 (5.2)
Vision impairment,	350 (31.6)
Hearing impairment	134 (12.1)
Speech impediment	679 (61.3)
Intellectual disability	702 (63.4)
Orthopedic disability	549 (49.5)
Other	31 (2.8)

SEM: Standard error of the mean.

2.8. Waterlow classification

The Waterlow classification makes the distinction between “wasting” (reflects acute malnutrition and is based upon weight-for-height) and “stunting” (which reflects chronic malnutrition and is based upon height-for-age). Using Waterlow Classification system, wasting (the percentage of expected WFH) and the degree of stunting (the percentage of expected HFA) were determined. Cases with malnutrition were further categorized in terms of severity based on % WFH [normal ($\geq 90\%$), mild (80–89%), moderate (70–79%), severe ($<70\%$)] and % HFA [normal ($\geq 95\%$), mild (90–94%), moderate (85–89%), severe ($<85\%$)] parameter [24]. While the classification was created using both WHO and Neyzi standard growth charts, it should also be noted that not every component of the WHO is available for all ages of children in the study and Neyzi does not have a WFH component and therefore only the “stunting” classification could be created for the Neyzi percentiles.

2.9. Physician questionnaire

Physician's view on nutritional status of children with CP was evaluated via application of a 6-item questionnaire that elicited data on physicians' clinical judgment on presence of malnutrition, necessity and type of nutritional therapy, follow up and referral of patient and most appropriate healthcare professionals to monitor a CP patient's nutritional status and main barriers to good nutrition in children with CP.

2.10. Statistical analysis

This study was planned as a large scale multi center non-interventional cross sectional study. Approximately 1000 children were expected to be enrolled. To attain this sample size, approximately 20 physicians (pediatricians) were asked to enroll around 50 subjects at each of their study sites. When the sample size reached 1000, a two-sided 95.0% confidence interval for a single proportion using the large sample normal approximation will extend 2.2% from the observed percentage assuming an expected prevalence of undernutrition of 14%. The software nQuery® Advisor 5.0 was used for sample size estimation.

All available data from all subjects who were enrolled were summarized with descriptive statistics. Categorical variables are summarized by n (%), continuous variables are summarized mean $\pm$ standard error of mean (SEM).

3. Results

3.1. Baseline patient and disease characteristics

Mean age of patients at enrollment and at CP diagnosis were 7.2 ± 0.1 years (61.0% aged <8 years) and was 30.6 ± 0.9 months (before 4 years of age in 79.2%), respectively. Males composed 59.3% of

the study population. Birth characteristics included average gestational age of 35 weeks, delivery via Cesarean section in 52.9% and parental consanguinity in 25.8% of patients. Mean Neyzi z-scores for WFA, HFA and HCFA at birth were -2.11 ± 0.07 , -1.28 ± 0.14 and -0.83 ± 0.24 , respectively (Table 1).

The three most common CP etiologies were asphyxia (62.5%), low birth weight (45.6%), and prematurity (44.5%), while multiple etiologies were evident in 59.3% of patients. The most common clinical category was spastic CP (87.5%) with quadriplegic (54.0%) or diplegic (31.2%) topography and GMFCS level V limitation (45.4%) in most of patients (Table 1).

Intellectual disability (63.4%), speech impediment (61.3%) and epilepsy (55.3%) were the three most commonly identified concomitant disorders and periventricular leukomalacia was the CT/MRI finding in 53.4% of patients, as followed by cerebral atrophy (19.9%) (Table 1).

3.2. Anthropometrics according to age groups

Mean z-scores for WFA and HFA using Neyzi growth standards were -1.95 ± 0.07 (ranged from -1.59 ± 0.10 in the 1–4 years of age to -3.51 ± 0.58 in >16 years of age) and -1.7 ± 0.07 (ranged from -1.35 ± 0.11 in the 1–4 years of age to -2.66 ± 0.38 in >16 years of age), respectively at the time of enrollment. Average WFA percentile values were 19.24 ± 0.85 in the overall study population, while 20.09 ± 1.50 (in ≥ 1 y ≤ 4 y), 21.28 ± 1.62 (in >4 y ≤ 8 y), 21.33 ± 1.99 (in ≥ 8 y ≤ 12 y) 10.90 ± 1.70 (in >12 y ≤ 16 y) and 13.52 ± 3.80 (in >16 y) in different age groups (Table 2).

3.3. Nutritional status, feeding method and concomitant gastrointestinal problems

Malnutrition was considered to be evident in 57.2% of patients based on physician's clinical judgment, and ranged from 41.0% in the >16 year age group to 59.4% in the >8 y ≤ 12 y age group (Table 3).

According to Gomez classification of WFA Neyzi percentiles, malnutrition was evident in 94.3% of patients (ranged from 92.3% in the >16 y age group to 96.8% in the >12 y ≤ 16 y age group) and classified as 3rd degree (percentile <60) malnutrition in 86.7% of patients (ranged from 83.7% in the >8 y ≤ 12 y age group to 92.2% in the >12 y ≤ 16 y age group), regardless of the age group (Table 3).

Waterlow (wasting) classification of WFH WHO percentiles revealed malnutrition in 55.6% of patients who aged 1–8 years (88.0% and 22.7% in 1–4 year and 4–8 year age groups, respectively), classified as severe malnutrition in 49.7% (77.7% and 21.2% in 1–4 year and 4–8 year age groups, respectively) (Table 3).

Waterlow (stunting) classification of HFA revealed malnutrition in 91.2% (severe in 87.8%) of patients based on WHO percentiles, and in 91.3% (severe in 88.3%), and decreased from 94.1% in 1–4 years to 79.5% in >16 years age groups of patients based on Neyzi percentiles in the overall study population (Table 3).

Oral feeding was the type of feeding in majority of cases (88.5%), while constipation (43.6%), lack of appetite (33.8%) and difficulty in swallowing (24.4%) were the most common concomitant gastrointestinal problems in the overall study population and in each age group (Table 3).

3.4. Malnutrition prevalence according to type of CP

According to physician's clinical judgment, malnutrition was evident in 59.1% of males and in 54.6% females, while spastic CP was associated with higher rates of malnutrition than not-spastic CP (58.2% vs. 51.1%), particularly among females (56.9% vs. 39.0%). In males, spastic vs. not-spastic CP revealed similar rates of malnutrition (60.0% vs. 39.0%), particularly for dyskinetic CP (67.3% vs. 32.1%) and mixed CP (80.0% vs. 50%) as compared to females (Table 4).

Gomez classification revealed similarly high prevalence of malnutrition and severe malnutrition in both spastic and not spastic CP as well as in subgroups of not spastic CP (Table 4).

Table 2
Anthropometric measurements according to age groups.

Anthropometrics		Age at enrollment					Total (n = 1108)
		≥ 1 y ≤ 4 y (n = 341)	>4 y ≤ 8 y (n = 335)	>8 y ≤ 12 y (n = 239)	>12 y ≤ 16 y (n = 154)	>16 y (n = 39)	
Body weight (kg), mean $\pm$ SEM							
Weight for age Z-score	Neyzi	-1.59 ± 0.10	-1.72 ± 0.11	-2.00 ± 0.15	-2.84 ± 0.19	-3.51 ± 0.58	-1.95 ± 0.07
	WHO	-1.29 ± 0.09	-1.50 ± 0.10	-1.78 ± 0.18	–	–	-1.46 ± 0.07
Weight for age percentile	Neyzi	20.09 ± 1.50	21.28 ± 1.62	21.33 ± 1.99	10.90 ± 1.70	13.52 ± 3.80	19.24 ± 0.85
	WHO	24.72 ± 1.65	22.88 ± 1.67	23.32 ± 2.72	–	–	23.72 ± 1.08
Height (cm), mean $\pm$ SEM							
Height for age Z-score	Neyzi	-1.35 ± 0.11	-1.46 ± 0.12	-1.91 ± 0.14	-2.54 ± 0.18	-2.66 ± 0.38	-1.70 ± 0.07
	WHO	-1.31 ± 0.13	-1.38 ± 0.12	-1.83 ± 0.14	-2.24 ± 0.17	-2.46 ± 0.34	-1.60 ± 0.07
Height for age percentile	Neyzi	23.14 ± 1.64	24.44 ± 1.77	18.82 ± 1.82	12.02 ± 1.79	12.21 ± 4.21	20.82 ± 0.90
	WHO	25.24 ± 1.77	25.03 ± 1.76	19.04 ± 1.80	14.43 ± 1.89	12.14 ± 3.79	22.00 ± 0.92
Head circumference (cm), mean $\pm$ SEM							
HC for age Z-score	Neyzi	-2.44 ± 0.12	-2.60 ± 0.12	-2.93 ± 0.18	-3.94 ± 0.20	-3.24 ± 0.49	-2.83 ± 0.07
	WHO	-2.03 ± 0.13	-2.22 ± 0.26	–	–	–	-2.07 ± 0.11
HC for age percentile	Neyzi	12.82 ± 1.28	12.53 ± 1.25	10.99 ± 1.42	4.39 ± 0.95	10.45 ± 4.02	11.09 ± 0.66
	WHO	18.74 ± 1.56	19.38 ± 3.04	–	–	–	18.88 ± 1.39
Body mass index (kg/m²), mean $\pm$ SEM							
BMI for age Z-score	Neyzi	-1.05 ± 0.12	-1.20 ± 0.13	-1.24 ± 0.15	-1.78 ± 0.18	-2.08 ± 0.60	-1.26 ± 0.07
	WHO	-0.63 ± 0.11	-0.85 ± 0.11	-0.98 ± 0.15	-1.40 ± 0.18	-1.14 ± 0.38	-0.89 ± 0.07
BMI for age percentile	Neyzi	33.11 ± 1.87	31.69 ± 1.88	31.01 ± 2.20	21.80 ± 2.44	27.87 ± 5.98	30.59 ± 1.02
	WHO	38.60 ± 1.97	34.70 ± 1.95	36.05 ± 2.40	29.34 ± 2.81	35.23 ± 5.78	35.55 ± 1.09
TSFT for age Z-score	WHO	-0.38 ± 0.13	-0.55 ± 0.15	–	–	–	-0.41 ± 0.10
MUAC for age Z-score	WHO	-1.47 ± 0.18	-1.52 ± 0.35	–	–	–	-1.48 ± 0.16

SEM: standard error of the mean; TSFT: Triceps skinfold thickness; MUAC: Mid upper arm circumference.

WHO growth charts are only available up to age 10 years and Neyzi charts do not include data on percentiles for TSFT and MUAC.

Table 3

Assessment of nutritional status, feeding method and concomitant gastrointestinal problems.

	Age at enrollment					Total
	≥1 y ≤ 4 y	>4 y ≤ 8 y	>8 y ≤ 12 y	>12 y ≤ 16 y	>16 y	
Nutritional status assessment, n (%)						
Physician's clinical judgment						
Normal	141 (41.3)	143 (42.7)	97 (40.6)	69 (44.8)	23 (59.0)	473 (42.7)
Malnourished	199 (58.4)	192 (57.3)	142 (59.4)	85 (55.2)	16 (41.0)	634 (57.2)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Gomez Classification (WFA WHO percentiles)^a						
Unknown	2 (0.6)	0 (0.0)	92 (38.5)	154 (100.0)	39 (100.0)	287 (25.9)
Normal	21 (6.2)	22 (6.6)	12 (5.0)	0 (0.0)	0 (0.0)	55 (5.0)
Malnourished	318 (93.2)	313 (93.4)	135 (56.5)	—	—	766 (83.7)
1st degree	15 (4.4)	17 (5.1)	6 (2.5)	0 (0.0)	0 (0.0)	38 (3.4)
2nd degree	14 (4.1)	15 (4.5)	11 (4.6)	0 (0.0)	0 (0.0)	40 (3.6)
3rd degree	289 (84.8)	281 (83.9)	118 (49.4)	0 (0.0)	0 (0.0)	688 (62.1)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Gomez classification (WFA Neyzi percentiles)						
Overall						
Unknown	2 (0.6)	0 (0.0)	2 (0.8)	3 (1.9)	3 (7.7)	10 (0.9)
Normal	16 (4.7)	20 (6.0)	15 (6.3)	2 (1.3)	0 (0.0)	53 (4.8)
Malnourished	323 (94.7)	315 (94.0)	222 (92.9)	149 (96.8)	36 (92.3)	1045 (94.3)
1st degree	8 (2.3)	14 (4.2)	8 (3.3)	2 (1.3)	1 (2.6)	33 (3.0)
2nd degree	15 (4.4)	16 (4.8)	14 (5.9)	5 (3.2)	1 (2.6)	51 (4.6)
3rd degree	300 (88.0)	285 (85.1)	200 (83.7)	142 (92.2)	34 (87.2)	961 (86.7)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Waterlow (wasting) classification of (WFH WHO percentiles)^{a,b}						
Unknown	10 (2.9)	246 (73.4)	239 (100.0)	154 (100.0)	39 (100.0)	688 (62.1)
Normal	31 (9.1)	13 (3.9)	0 (0.0)	0 (0.0)	0 (0.0)	44 (4.0)
Malnourished	300 (88.0)	76 (22.7)	—	—	—	376 (55.6)
Mild	14 (4.1)	2 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	16 (1.4)
Moderate	21 (6.2)	3 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	24 (2.2)
Severe	265 (77.7)	71 (21.2)	0 (0.0)	0 (0.0)	0 (0.0)	336 (30.3)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Waterlow (stunting) classification (HFA WHO percentiles)						
Unknown	4 (1.2)	16 (4.8)	13 (5.4)	16 (10.4)	4 (10.3)	53 (4.8)
Normal	22 (6.5)	15 (4.5)	7 (2.9)	0 (0.0)	0 (0.0)	44 (4.0)
Malnourished	315 (92.3)	304 (90.7)	219 (91.7)	138 (89.6)	35 (89.7)	1011 (91.2)
Mild	4 (1.2)	12 (3.6)	4 (1.7)	2 (1.3)	1 (2.6)	23 (2.1)
Moderate	6 (1.8)	5 (1.5)	2 (0.8)	2 (1.3)	0 (0.0)	15 (1.4)
Severe	305 (89.4)	287 (85.7)	213 (89.1)	134 (87.0)	34 (87.2)	973 (87.8)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Waterlow (stunting) classification (HFA Neyzi percentiles)						
Unknown	4 (1.2)	16 (4.8)	13 (5.4)	16 (10.4)	7 (17.9)	56 (5.1)
Normal	16 (4.7)	16 (4.8)	7 (2.9)	0 (0.0)	1 (2.6)	40 (3.6)
Malnourished	321 (94.1)	303 (90.4)	219 (91.7)	138 (89.6)	31 (79.5)	1102 (91.3)
Mild	8 (2.3)	12 (3.6)	3 (1.3)	1 (0.6)	0 (0.0)	24 (2.2)
Moderate	2 (0.6)	4 (1.2)	2 (0.8)	2 (1.3)	0 (0.0)	10 (0.9)
Severe	311 (91.2)	287 (85.7)	214 (89.5)	135 (87.7)	31 (79.5)	978 (88.3)
Total	341 (100.0)	335 (100.0)	239 (100.0)	154 (100.0)	39 (100.0)	1108 (100.0)
Feeding method, n (%)						
Normal, orally	303 (88.9)	280 (83.6)	216 (90.4)	144 (93.5)	38 (97.4)	981 (88.5)
PEG feeding	17 (5.0)	43 (12.8)	13 (5.4)	8 (5.2)	1 (2.6)	82 (7.4)
NG/OG feeding	13 (3.8)	11 (3.3)	9 (3.8)	2 (1.3)	0 (0.0)	35 (3.2)
Gastrointestinal problems, n (%)						
Vomiting	48 (14.1)	43 (12.8)	28 (11.7)	15 (9.7)	3 (7.7)	137 (12.4)
Diarrhea	14 (4.1)	2 (0.6)	4 (1.7)	1 (0.6)	0 (0.0)	21 (1.9)
Constipation	142 (41.6)	159 (47.5)	100 (41.8)	64 (41.6)	18 (46.2)	483 (43.6)
Difficulty in swallowing	70 (20.5)	84 (25.1)	65 (27.2)	45 (29.2)	6 (15.4)	270 (24.4)
Lack of appetite	104 (30.5)	126 (37.6)	77 (32.2)	55 (35.7)	12 (30.8)	374 (33.8)

WFA: weight for age, WFH: weight for height, HFA: height for age, NA: not available for the age group.

^a WHO growth charts are only available up to age 10 years.^b Neyzi growth chart does not have a WFH component.

3.5. Physicians' view on nutritional status and management of malnutrition

According to physician's view, 57.2% of sampled children with CP was considered to be malnourished. Physicians identified that they consider provision of nutritional management a priority (56.9%) with use of regular homemade food (52.9%) and oral nutritional products (42.7%) in most cases (Table 5).

Overall 76.4% of physicians identified that they would consider follow up patient and for 6–12 months in

majority of cases (91%), while 20.2% identified that they would refer patients, mostly to a pediatric gastroenterologist (79.0%) (Table 5).

Physicians considered dietitians (37.0%), pediatric neurologists (32.2%) and pediatric gastroenterologists (20.2%) to be the most appropriate healthcare professionals to monitor a CP patient's nutritional status. Parents' lack of knowledge (46.2%) and lack of attention to diet (24.1%) were identified by the physicians as the two most common barriers to good nutrition in children with CP (Table 5).

Table 4

Malnutrition prevalence according to clinical category of CP based on physician's clinical judgment and anthropometric data.

CP clinical category	Nutritional status assessment								
	Physician's clinical judgment						Gomez classification (WFA percentiles using Neyzi charts)		
	Total		Male		Female				
	N	malnourished	N	malnourished	N	malnourished	N	malnourished	3rd degree
CP clinical category									
Spastic	968	563 (58.2)	578	341 (59.0)	390	222 (56.9)	962	913 (94.9)	835 (86.8)
Not spastic	137	70 (51.1)	78	47 (60.3)	59	23 (39.0)	134	130 (97.0)	124 (92.5)
Dyskinetic	77	42 (54.5)	49	33 (67.3)	28	9 (32.1)	76	73 (96.1)	71 (93.4)
Ataxic-hypotonic	45	19 (42.2)	24	10 (41.7)	21	9 (42.9)	44	43 (97.7)	40 (90.9)
Mixed	15	9 (60.0)	5	4 (80.0)	10	5 (50.0)	14	14 (100.0)	13 (92.9)
Total	1105	633 (57.3)	656	388 (59.1)	449	245 (54.6)	1096	1043 (95.2)	959 (87.5)
Missing data	3		1		2		12		

WFA: Weight for age.

4. Discussion

Our findings in a cohort of 1108 pediatric outpatients with CP from 20 centers across Turkey revealed the diagnosis of spastic CP in majority of patients alongside quadriplegic topography, GSMCF level V motor dysfunction and co-morbid intellectual disability, speech impediment, epilepsy and gastrointestinal problems in a considerable portion of patients.

The prevalence of malnutrition was considered to be 57.2% based on physicians' clinical judgment, while shown to be 94.3% (3rd degree in 86.7%) according to Gomez classification of WFA percentiles and to be 91.3% (severe in 88.3%) according to Waterlow classification of HFA percentiles.

Table 5

Physician's view on nutritional status and management of malnutrition.

Physicians considered	n (%)
Patient to be malnourished	634 (57.2)
Provision of nutrition treatment	630 (56.9)
Blenderized food	162 (14.6)
Oral nutritional products	473 (42.7)
Tube feeding - NG/PEG	129 (11.6)
Parenteral feeding	3 (0.3)
Regular homemade food	586 (52.9)
Other	3 (0.3)
NA	10 (0.9)
Follow up of patient	846 (76.4)
For 3-month	51 (5.9)
For 6-month	324 (37.7)
For 12-month	458 (53.3)
N/A	9 (1.0)
Referral of patient to	224 (20.2)
Pediatric gastroenterologist	184 (79.0)
Dietitian	45 (19.3)
Other	1 (0.4)
Most appropriate health care professional to follow up patient	
Dietitian	408 (36.8)
Family doctor	84 (7.6)
Pediatric gastroenterologist	224 (20.2)
Pediatric neurologist	357 (32.2)
Other	13 (1.2)
N/A	22 (2.0)
Biggest barrier to good nutrition	
Physicians' lack of awareness	82 (7.4)
Physicians' lack of knowledge	20 (1.8)
Lack of attention to diet	267 (24.1)
Time commitment necessary	204 (18.4)
Parents' lack of knowledge	512 (46.2)
N/A	23 (2.1)
Total	1108 (100.0)

For some questions there could be more than 1 answer and therefore the percentages are not expected to add to 100%.

Our findings support high prevalence of malnutrition reported in children with CP, particularly in case of higher levels of gross motor dysfunction [7,10–14,25,26]. Dominance of spastic CP category with quadriplegic topography and GSMCF level V motor limitation in our cohort seems consistent with consideration of non-ambulatory status amongst the strongest risk factors for malnutrition in children with CP [15].

There was a remarkable discordance between physicians' clinical judgment and use of anthropometric data in terms of identification of malnutrition (~50% vs. 90%) in our cohort of children with CP. Malnutrition is considered to be generally unrecognized and unmanaged in clinical practice with insufficient awareness of physicians regarding nutritional assessment and intervention in high-risk patients [19]. However, use of anthropometric charts for general references in healthy children in the assessment of nutritional status of children with CP has been associated with malnutrition rates that range from 40% to 90% depending on the study population and anthropometric assessment method [18,26–31].

Moreover, practitioner's clinical judgment rather than objective anthropometric data has been associated with estimation of higher rates of malnutrition due to likelihood of detecting patients at risk of developing malnutrition prior to occurrence of anthropometric and laboratory changes [32].

Children with CP differs from healthy children in terms of weight, height and BMI as well as body composition and sexual maturation [8,14,33,34]. This discrepancy is considered to be associated not only with nutritional status but also with the type and severity of neurological deficit, ambulation, cognitive ability and neuro-endocrine factors [8,14,33,34].

Accordingly, on the basis of low correlation between standard growth charts and specific references for CP and increase in discordance between CP-specific and general reference curves with higher severity of motor impairment, utility of curves specific to CP population has been emphasized in nutritional assessment of children with CP [13,18,21,26].

Spastic CP was the clinical category in majority of our patients along with quadriplegic topography and GSMCF level V motor limitation in a considerable portion of patients. Thus, the discordance between physicians' clinical judgment and anthropometric measurements in identification of malnutrition in our cohort seems to be linked to challenges inherent in anthropometry in children with CP, emphasizing the likelihood of over-estimating malnutrition when nutritional assessment was based on standard growth charts in children with CP. This seems notable given the importance of setting more realistic nutritional goals in terms of more focused utilization of healthcare resources and nutritional interventions in children with CP [8,18,35,36].

While majority of patients in each age group was on normal oral feeding in our cohort, concomitant gastrointestinal problems such as constipation, lack of appetite and difficulty in swallowing was noted in most of patients. This supports the frequent presence of gastrointestinal problems among children with neurodevelopmental disabilities that include oral motor dysfunction and consequent challenges related to feeding difficulties, risk of aspiration, prolonged feeding times, reduction in nutrient intake and malnutrition [12,37–40]. Alongside spastic CP with severe motor impairment, high prevalence of gastrointestinal problems in our cohort seems also notable given the higher interference of more severe neuro-impairment with nutritional impairment and anthropometric deficits in curves, creating greater risk of hospitalizations, school absences, impaired neuro-psychomotor development and mortality [16,18,41,42].

Indeed, only 11.6% of physicians in this study identified that they consider tube feeding (NG/PEG) in the provision of nutritional management, while majority indicated choice of regular home-made food or oral nutritional products. This seems notable given that while cerebral palsy is amongst the indications for enteral nutritional support in children with inadequate oral intake and total feeding time in a disabled child >4–6 h/day is a suggested criteria for nutritional support [43].

Accordingly, implementation of a multidisciplinary approach with participation of pediatric neurologists, pediatric gastroenterologists, nurses, occupational therapists, and dietitians has been emphasized to enable detailed assessment and earlier recognition of the feeding/swallowing related malnutrition signs and thus appropriate management of malnourished children with neurological disability [10,38,44,45].

Notably, the physicians participated in this study considered parents' lack of knowledge and lack of attention to diet rather than physician's awareness and lack of knowledge to be the main barriers to good nutrition in children with CP. They also identified dietitians, pediatric neurologists and pediatric gastroenterologists as the most appropriate healthcare professionals to monitor nutritional status in children with CP. Additionally, they considered provision of nutritional management a priority in malnourished children with CP.

Use of Gomez classification was associated with high prevalence of malnutrition regardless of age group and type of CP, whereas a tendency for lower rates of malnutrition was considered in case of physician's clinical judgment and use of Waterlow (stunting) classification.

In fact, there was a tendency for poorer mean z-scores and percentiles for WFA and HFA with advanced age in our cohort, supporting the exhibition of more linear growth patterns lacking a growth spurt by children in GMFCS level V [13]. In addition, children with severe motor impairments are considered to be shorter, lighter, and thinner due to a negative correlation between height or weight z scores and GMFCS level [26,46,47].

5. Conclusion

In conclusion, our findings in a large-scale cohort of pediatric outpatients with CP across Turkey revealed the diagnosis of spastic CP in majority of patients alongside quadriplegic topography, GSMCF level V motor dysfunction and co-morbid intellectual disability, speech impediment, epilepsy and gastrointestinal problems. Our findings support the high prevalence of malnutrition in children with CP and emphasize the consideration of co-morbid gastrointestinal problems and nonneuromotor impairments in the management of CP given their potential to predict and deteriorate the nutritional status. A remarkable discordance was noted between physicians' clinical judgment and anthropometric

data-based assessment of nutritional status in terms of prevalence of malnutrition, emphasizing likelihood of overestimation of malnutrition in children with CP when anthropometric assessment was based on use of growth charts for general pediatric population. Thus, our findings emphasize using appropriate tools and specific curves in assessing nutritional status of children with CP to obtain a more reliable anthropometric profile and more realistic nutritional goals in nutritional rehabilitation. This large-scale survey provided valuable data regarding nutritional assessment practice and malnutrition prevalence among children with CP in Turkey, which may be utilized for future proactive strategies in the prevention and treatment of malnutrition in this population.

Conflict of interest

The author declares that he has no conflict of interest.

Statement of authorship

Kursad Aydin agreed to be fully accountable for ensuring the integrity and accuracy of the work and had primary responsibility for final content on behalf of the Turkish Cerebral Palsy Study Group.

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