Malnutrition is Common in Cerebral Palsy Children in Saudi Arabia – A Cross-Sectional Clinical Observational Study

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Abstract

Background: Cerebral palsy is the main cause of severe physical impairment and malnutrition in children. This cross-sectional study intended to survey the nutritional status of cerebral palsy children in Riyadh, Saudi Arabia. Methods: We examined 74 children (age: 1-10 yrs) with cerebral palsy, who attended Sultan Bin Abdulaziz Humanitarian City (SBAHC), Riyadh Saudi Arabia. Data on age, general demographics, nutritional status and dietary intake were collected. A child was considered underweight, wasted, stunted or thin if the standard deviation scores for his/her weight for age, weight for height, height for age and body mass index for age was \( \leq -2.0 \) SD using WHO growth standards. Multivariable logistic regression identified the factors associated with nutritional indicators. Results: More than half (56.4%) of the children with cerebral palsy were malnourished as they had z-score below <-2 SD in at least one of the four indicators. Thinness (50%) was the most common form of malnutrition, followed by underweight, stunting and wasting. Arm anthropometrics gave similar results on the percent number of malnourished children. Factors that were independently associated with malnutrition with an adjusted OR (aOR) were as follow: age \( \leq 5 \) yrs (aOR: 4.29); presence of cognitive impairment (aOR: 4.13); presence of anemia (aOR: 3.41) and inadequate energy intake (aOR: 4.86) (p, for all trends <0.05). Conclusion: Cerebral palsy children of the current study have impaired growth and nutritional status as assessed by all four common nutritional status indicators. Further large-scale community-based studies for in-depth evolution of nutritional status and growth patterns in cerebral palsy children are needed.

Background

Cerebral palsy (CP) has been recognized as one of the major causes of physical disability in children worldwide [1-3]. There may be variations in the prevalence of CP in children
mainly because of the inconsistency of definition and classification that generate seemingly controversial results and conclusions or because of the methodological variations [4]. Nevertheless, the associated nutritional problems resulting from the disorder can be visualized to be serious both in severity and scope [3]. Impairment of sensation in cerebral palsy stays for the whole lifespan [5], therefore, related issues, importantly nutritional, are likely to sustain throughout the life if not addressed promptly. Nutritional status is significantly affected in children with CP [1-2, 6-7]. The associated comorbidities include growth abnormalities, feeding complications, communication disorders, mental obstruction, seizure disorders, and auditory and visual deficiency [8-9]. With the diminished motor and mental capabilities, the patient is unable to eat properly and is very likely to have suboptimal energy intake. Investigating a possible relation between the poor dietary intake and the presence of feeding dysfunction in CP children has been one of the prime interests of most investigators in this field [10].

Most of the studies done in developed countries show that factors like inadequate nutrient intake, feeding problems, and motor dysfunctions are associated with poor nutritional status in CP children [1-2, 11-13]. No data, however, currently exist that report nutritional status of CP children in Saudi Arabia despite a high prevalence of this disorder in children in this country [14]. Neither, there are any studies that address the contributing factors for malnutrition in CP children in Saudi Arabia. Worldwide, relatively fewer studies authenticating the importance of nutrition in CP children are existing and these are essentially missing for Saudi Arabia. Our hypothesis is that Saudi children with CP would demonstrate poorer nutritional status compared to otherwise normal children. Therefore, we aimed in this study to examine nutritional status of CP children attending a care and rehabilitation clinic in Riyadh Saudi Arabia. Another aim of the current study was to establish factors that have a potential association with nutritional status in children with
the disease.

Methods

Study Settings

The study was conducted in Sultan Bin Abdulaziz Humanitarian City (SBAHC), Riyadh Saudi Arabia. SBAHC is 400-bedded medical and rehabilitation center which caters medical and rehabilitation care outpatients and inpatients. Having an interdisciplinary approach and an integrated organizational structure, the patients are treated in a more specialized manner according to patients’ needs and disabilities.

Ethical approval

The study design for the current study was approved by the Research Ethics Committee at College of Applied Medical Science, King Saud University, Riyadh, Saudi Arabia. Written consents for participation in the study were obtained from the parents or guardians of the CP children prior to the commencement of the study.

Location, size, and selection of the sample

Children patients with CP, aged 1-12 years admitted to SBAHC, who met the CP diagnosis criteria [15-17], were consecutively recruited from children visiting the CP clinic. Given the limitations of time and resource, the study used a convenience sample. Initially, 101 children met the eligibility criteria, but consent was only obtained from the caregivers of 80 children. Final data could be completed on 74 children as 6 children dropped out due to various reasons. Information about the socio-demographic and clinical characteristics of the study population is presented in Table 1.

Study Design

Assessment was made in three steps as reported elsewhere [8]. Briefly, all children were diagnosed and confirmed as ‘cerebral palsy’ by a developmental pediatrician and/or neurologist at the center.
In step 1, a ‘Ten Question Screen’ was used for initial screening [13]. For the purpose of this study, CP was defined as: “a group of brain damage syndromes resulting into non-progressive and static cerebral lesions that further produces significant motor delay that may cause abnormal neuro-motor findings beginning during the developmental period and other central nervous system deficits in areas of cognition and neuro-behavior” [13]. In the second step, a physiotherapist further assessed the patients following the decision tree for identification of cerebral palsy [14]. In the third and final step, the developmental pediatrician and/or neurologist confirmed CP and classified the disease using the Gross Motor Function Classification System (MFCS) level I-V as mentioned elsewhere [18].

Briefly, MFCS is a validated 5-level scale that classifies the severity of motor impairment in children with cerebral palsy. Gross motor skills are based on developmental milestones, and the items of the scale are distributed among 5 dimensions (A = lying, rolling; B = sitting; C = crawling, kneeling; D = standing; E = walking, running, and jumping). The GMFCS level was classified by the child’s physiotherapist under the supervision of pediatrician. The medical records of the participants eligible for the study demonstrated the diagnoses of CP had been made when the patient was more than 6 months of age and all required diagnosis relating to mental retardation or other developmental delays were primarily completed by the school personnel or the developmental pediatricians. The exclusion criteria were not to consider those patients who had metabolic, genetic, or neuro-degenerative diseases or with any medical infections known to affect nutritional and growth status in any way. Also, patients fed through enteral or parenteral routes or patients receiving corticosteroids or other medication/drugs known to have an influence on growth were excluded [7].

Data Collection: Data were collected in the following distinct stages [8]:

1. Structured Interviews. The caregivers were interviewed using a well-structured
questionnaire. Questions were included to get information on diet intake, feeding problems and other associated factors that could contribute to nutritional status [7].

2. Physical and Cognitive Examination. Gross and fine moor functions were assessed based on the child ability to sit, to grasp and on self-initiated walking and fine moor skills [18]. Cognitive impairment assessment was performed as a routine clinical practice. Data on cognitive assessment were collected from the patients’ hospital file. In general, all children were assessed for cognitive impairment by a neurologist on a Mini-Mental State Examination (MMSE) adapted and validated by Jain and Passi [19] for children on the basis of a system of scores for cognitive impairments. This instrument assesses the mental functions of language, temporal and spatial orientations, attention, constructive praxis and memory [20]. The test comprehensively assess the visual/verbal attention and visual/verbal short/long term memory. Jain and Passi [19] defined a cutoff point for cognitive deficit of two standard deviations below the mean. Our interest in the cognitive ability of children with CP was to include only those children who had medium-to-high.

3. Anthropometric Measurements. Anthropometric measurements included weight, height, arm circumference (AC), arm muscles circumference (AMC), and triceps skinfold thickness (TST). Weight (kg) and height (cm) were measured [8]. Weight was recorded on Scale-Tronix model 2002 single scale (Dynamic Scales, Inc. 1466 South 8th Street Terre Haute, IN 47802, USA). For children who could stand easily and erectly, the height was measured with a scale with a fixed and attached stadiometer (SECA 789, Hamburg, Germany). In case it was not possible or difficult to measure the standing height because of the inherent contractures or scoliosis, height was estimated from the knee-height using available authenticated equations [6]:

\[ \text{Height cm} = 2.69 \times \text{knee height in cm} + 24.2 \]

The procedure for measuring knee-height was completed while the patient was in the
supine position. The common stretchable measuring tape was used for the measurement. All measurements were done in triplicate and the average was considered. All measurements were done in the morning by the same experienced examiner.

AC was measured using non-elastic measuring tape. TST was measured with skinfold caliper (Lange®; Power Systems, Inc., Tennessee, USA). AMC was calculated using an equation [21] as:

\[ AMC_{cm} = AC_{cm} - \pi \times TST_{mm} \div 10 \]

All measurements were done in duplicate by the same person and the mean values were used for final analysis.

4. Dietary. Dietary data were obtained by 3-days dietary records, kept by parents/caregivers or nurses of cerebral palsy children. Prior to data collection, the parents/caregivers or nurses were educated on how to measure food quantities according to the food materials that were used in the diet clinic. Nutrients were calculated from the contents of the 3-day food diaries using the Arab food analysis program (HBCN; health balance for clinical nutrition, Riyadh, Saudi Arabia) diet analysis software. The calorie and protein intake of cerebral palsy children were compared with the estimated average intake as reference (22).

5. Assessment of feeding problems of CP children. A speech and swallowing therapists assessed the feeding problems of CP children. Questions were also asked to know feeding problems (yes/no) and appetite status of the children (normal/fair vs. poor) from the parents/caregivers. For this purpose, a questionnaire, based on recommendations from previously published reports [8-13] was designed in such a way to identify the most common feeding problems including inability to self-feed, inadequate/absence of tongue lateralization, chewing problem, swallowing problem, cough/choking during feed, drooling,
hypertonic tongue, inability to take solid food, constipation, sucking problem, vomiting/regurgitation, non-closure of lips around spoon, Inappropriate wide mouth opening and cry/extensor dystonia during feeding.

5. Laboratory Investigations. Under aseptic conditions, 5 ml blood was drawn and serum creatinine was quantified using the ethylene-diamine-tetraacetic acid tubes. Hemoglobin, red blood cells (RBC) and hematocrit were quantified using gel tubes. All parameters were measured using routine laboratory procedures. Normal ranges for Hb, creatinine, RBC and hematocrit were used to classify the children ‘within normal range’ and ‘within abnormal range’ (see Additional File 1).

Data Handling

BMI was calculated from the weight and height of the patient (BMI = weight [kg]/height [m²]). Weight, height, and BMI values were used to calculate the sex and age normalized z-scores using the reference data for normal and healthy children [23]. Sex and age normalized z-scores were calculated using WHO Anthro- (2010) and AnthroPlus (2009). Children with extreme z-scores were excluded from the final calculations (8). The weight-for-age z-score was only calculated for children up to 10 years of age and the weight-for-height z-score for those up to 5 years of age [8]. Nutritional status of each child was assessed on the basis of z-scores. For the purpose of interpretation, a weight-for-age z-score < 2 was defined as underweight; height-for-age z-score < 2 was defined as ‘stunting’; weight-for-height z-score < was defined as ‘wasting’ whereas BMI-for-age z-score < 2 was defined as ‘thinness’ as reported [3,8]. Classification of nutritional status was performed using arm anthropometrics, i.e. AC, AMC, and TSF. Reference values proposed by Frisancho [24] (for children older than 1 year of age) and Jelliffe [25] (for those younger than 1 year) were used. Definitions of anthropometric indicators and normal ranges for Hb, creatinine, RBC and hematocrit are summarized in additional file.
Statistical Analysis

Statistical Program for Social Sciences database (IBM, SPSS, version 23, USA) was used for the analyses of the data that were expressed as percentages and mean (SD). Pearson's chi-square test was used to determine any association between the factors considered and the dependent variables of stunting, underweight, wasting and thinness. Co-occurrence of more than two indicators of nutritional status in a single child was depicted using a Venn diagram and consequent correlation between nutritional indicators were calculated based on Venn diagram as reported previously [8]. Factors such as age and type of cerebral palsy were categorized, and the adjusted odds ratios (aORs) with corresponding 95% confidence intervals (CIs) were computed. A p-value <0.05 was considered significant.

Results

We initially included a total of 101 children who visited SBAHC, Riyadh Saudi Arabia. However, we could only get complete data on 74 children for our final analyses. Twenty five patients were dropped at various stages of the study. The most common reason for drop-out was time constraint on the part of the care-givers (90%). The number of male/female patients was 30/44 (41.5%/59.5%) (mean age: 58.66 ± 30.99 months, range 19 - 144 months and 72.06 ± 33.05 months: range 27 - 144 months, respectively). The mean age of the patients as a whole was 66.70 ± 32.72 months (age range 19 - 144 months). All the patients were Saudi nationals. Most of cerebral palsy children in the age group < 5 yrs were in GMFCS level IV and V as shown in the additional file (see Additional File 2).

Table 1 shows some of demographic and clinical characteristics of the total 74 children with cerebral palsy; with 41 (55.4%) children in the malnutrition status group and 33 (45.6%) in the normal nutritional status group. A comparison between the two groups
(columns 3 and 4; Table 1) shows an over-representation in the malnutrition group of girl children than boys; of children > 5 yrs of age; of children with severe neuro-motor skill (GMFCS level IV-V), of children with inadequate energy and protein intake, of children with feeding problems and poor appetite, and finally of children with presence of cognitive impairment and anemia.

More than half (56.8%; n=42 of 74) of the children with CP were malnourished as they had z-score below < -2 SD in at least one of the indicators (Fig 1). As shown in Fig. 1, thinness (BMI for age z-score; BAZ) was the most common form of malnutrition; prevalent in 37 of 74 children (50%); followed by underweight (weight for age z-score; WAZ) in 31 of 74 children (51.4%). The least common form of malnutrition was wasting (weight for height z-score; WHZ) in 12 of 48 children followed by stunting (height for age z-score; HAZ) in 25 of 74 children (25% and 33.8%, respectively).

Distribution of children z-score for the four indices in relation to the WHO growth charts [23] showed a negatively skewed distribution for all indicators as shown in the additional file (see Additional File 3). Some children had z-score values much above/below the default flag limits for individual indicators and hence were removed from final calculations [8]. Overall, all indices were far below the threshold levels and the mean scores varied between -1.30 to -2.17 (Table 2).

Several children had poor nutritional status based on more than one of the nutritional status indicators [8] (Fig. 2). It was found that 8 children had a combination of three indicators, such as being underweight (low weight-for-age z-score), stunting (low height-for-age z-score) and wasting (low weight-for-height z-score), while 11 children had a combination of two of the indicators (Fig. 2A). Similarly, 10 children had a combination of thinness (low BMI-for-age z-score), stunting (low height-for-age z-score) and underweight (low weight-for-age z-score), with 24 having a combination of two of these indicators.
(Fig. 2B). This co-occurrence of several indicators of poor nutrition status within the same child yielded interesting results: for example, there was a positive correlation in the whole group between the parameters of underweight (low weight-for-age z-score) and stunting (low height-for-age z-score) \((r = 0.356, p=0.021)\); underweight (low weight-for-age z-score) and thinness (low BMI-for-age z-score) \((r = 0.356, p=0.033)\); and finally stunting (weigh-for-age z-score) and wasting (low weight-for-height z-score) \((r = 0.367; p = 0.042)\).

The classification of nutritional status assessed by AC demonstrated that a high number of children with CP (39%) had some degree of malnutrition. The AMC and TST, respectively, showed that 35% and 42% of the children with CP were malnourished (Table 3).

### Nutrients Intake

As a whole, in general children had lower intake of energy and protein than the recommended amounts. Data on percent cerebral palsy children with adequate energy and protein intake are shown in Fig. 3. Overall, slightly more than half children had adequate energy (55%), while less than half (49%) had adequate protein intake. Furthermore, children < 5 yrs of age were well up regarding energy and protein intake as there were more children <5 yrs of age with adequate energy and protein intake.

### Factors Associated with Poor Nutritional Status

Table 4 shows association between some selected demographic and clinical variables and malnutrition. Our adjusted analysis show that children were most likely to be malnourished if they were younger than 5 years of age \((p = 0.046)\), had cognitive impairment \((p = 0.032)\), had anemia \((p = 0.026)\) and had inadequate energy intake (i.e. < than 75% of RI) \((p = 0.043)\).

### Discussion

To the best of our knowledge, this is the first study which reports nutritional status of children with CP in the Kingdom of Saudi Arabia. Our findings suggest that impaired
Nutritional status was substantially prevalent in CP children participated in this study. Our data show that more than half (56.8%) were malnourished. Frequency of underweight (WAZ: weight-for-age z-score), ‘stunning’ (HAZ: height-for-age z-score), wasted (WHZ: weight-for-height z-score) and ‘thinness’ (BMI-AZ: BMI-for-age z-score) was 41.9%, 33.8%, 25%, and 50%, respectively. These are relatively higher prevalence rate than reported in previous studies on clinical samples both from low income [26] and high income countries [27]. A recent study by Kakooza-Mwesige and colleagues in 2015, however, has reported 52% of cerebral children, who visited clinics, were malnourished [8]. This prevalence rate of malnutrition in CP children is in close agreement to our findings.

In current study, thinness was the most prevalent form of malnutrition (50%); followed by underweight (41.9%), stunting (33.8%) and wasting (25%). These are high figures when compared to the prevalence in the otherwise normal Saudi children. For example, the prevalence of underweight, wasting, and stunting reported in normal Saudi children was 8.1%, 12.7% and 13.7%, respectively [28]. These data clearly indicate substantially a huge difference in rate of malnutrition between normal Saudi children and Saudi children with CP. One possible explanation for such a high difference maybe that the caregivers lacked handling CP children in a better way [8]. Another explanation for relatively higher prevalence rate of malnutrition in children with CP in our study may be that these are the most severe cases of cerebral children who needed to be taken to the clinics. This assumption necessitates a need for further exploration of CP in community settings. In our subjects wasting assessed by weight-for-height z-score (WHZ) (25%) was less prevalent than stunting (33.8%). Nevertheless, wasting reflects a recent weight loss history and has been shown to be an increased risk of dying [23, 29]. This situation, in particular, needs urgent attention and intact nutritional therapy [23].

Underweight (weight-for-age z-score) was the second most common nutritional problem
(41.9%) in CP children in current study. Underweight can transpire due to chronic or acute malnutrition in children as loss in weight can occur due to stunting (chronic malnutrition) or wasting and thinness (acute malnutrition) or a combination of these. In our sample, 41.3% children with CP were underweight (Fig 1). This is as much as almost 4 times higher prevalence rate as compared to normal Saudi population [28]. The percent of underweight children in our study are, however, comparable to those reported earlier in Uganda (42%) (8), Greece (38.1%) [30], but lower than those reported for Egyptian cerebral palsy children [31]. Such differences, if any, may be attributed to differences in methodological approaches and using different standard growth charts for comparison [12].

Malnutrition assessed by arm anthropometry gave interesting results (Table 3). High number of children were classified suffering from malnutrition assessed by AC (39%), AMC (35%) and TST (42%). Arm anthropometry describes body composition in relation to weight and should be used to provide additional data when analyzing growth [32]. The use of AC as an index of protein stores is well recognized [33]. Studies show a reduction in fat-free mass in patients with NPCE due to impaired linear growth, muscle mass depletion and atrophy [34]. The present study, when assessing the fat-free mass by AMC, found different results from those reported in the literature, as most patients had a nutritional classification of normal weight, evidencing that the lean body mass of the assessed patients was still preserved. TST is used in determination of body fat and also allows for the assessment of nutritional status. This appears to be the simplest and most practical method available to determine both subcutaneous and total body fat [34]. One study demonstrated that the measurement of triceps skinfold has sensitivity and specificity to predict malnutrition [35].

Factors Associated with Malnutrition:
Age, cognitive impairment, anemia, and inadequate energy intake were the factors that were found associated with malnutrition (Table 3). Children ≥ 5 years of age were more likely to suffer from malnutrition (p = 0.04: aOR: 4.29 (1.46 to 12.58); children with cognitive impairment were more than 5 times more likely to suffer from malnutrition (p = 0.032: aOR: 5.10 (1.66 to 15.70); children who had anemia were more than 3 times more likely to suffer from malnutrition (p = 0.026: aOR: 3.41 (1.28 to 9.12); and finally those who had inadequate energy intake were almost 5 times more likely to be suffering from malnutrition (p = 0.043; aOR: 4.86 (1.61 to 14.66). Cognitive impairment and age has been shown to be related to all forms of malnutrition in children with CP [8, 12-13]. For example, Kakooza-Mwesige et al., found that child age (above 5 yrs) and cognitive impairment were the two factors that were associated to more than two of the indicators/indices of nutritional status in children with CP [8]. Some studies, however, found deteriorating of linear growth z-score with age [e.g., Ref 36], while other showed a declining number with malnutrition with age [8]. These may be attributed to factors like reduced survival rate of CP children over the age of 5 as suggested by Kakooza-Mwesige et al., [8] and needs further investigations.

The current study had some strengths as well as limitations. The main strengths include the use of well-elaborated and finely formulated inclusion/exclusion criteria, appropriate methodology, and careful data collection. The main limitations of this study include its cross-sectional nature, inability to conduct body composition analysis and relatively small and an uneven distribution of the sample of patients with CP with various levels of neuro-motor severity and hence a possible bias in the interpretation of the results. Because of relatively small sample size, it was not possible to associate the circumference and skinfold assessments to the other anthropometric indicators (HAZ, WAZ, and WHZ, and BAZ). Future studies may consider these limitations and particularly investigate any
association between growth deviations (assessed by HAZ, WAZ, and WHZ, and BAZ) and wasting of muscular and subcutaneous fat (assessed by arm anthropometry).

**Conclusion**

In summary, from the data of the present study, it may be concluded that the cerebral palsy children have inappropriate dietary patterns, impaired nutritional status, and poor growth, especially in relation to weight. These results seriously highlight the greatest significance of primary nutritional screening, periodical nutritional assessment and integrated nutritional management of cerebral palsy children. If not addressed properly, the nutritional problems will multiply [37], and the disease burden will increase both in horizontal and vertical directions. Furthermore, there is a budding shortfall of a specialist dietitian involved in the nutritional care of cerebral palsy children in Saudi Arabia, for whom appropriate and expert dietetic support should be the most important therapeutic objectives.

Further research should consider nutrition quality in CP children and incorporate all nutritional care components. Further research may also consider examining the longitudinal effects of macronutrient intake on body composition parameters in CP children. Contributing factors like physical activity levels may also be concomitantly investigated in order to determine body composition changes and the associated effects on overall health of CP children [38].

**List Of Abbreviations**

AC: Arm Circumference

AMC: Arm Muscle Circumference

BMI: Body Mass Index

BMIAZ: Body mass index (BMI)-for-age z-score
CP: Cerebral Palsy
GMFCS: Gross Motor Function Classification Scale
HAZ: Height-for-age z-score
Hb: Hemoglobin
Ht: Hematocrit
RBC: Red Blood Cells
TST: Triceps Skinfold Thickness
WAZ: WAZ Weight-for-age z-score
WHZ: Weight-for-height z-score

**Declarations**

**Ethics approval and consent to participate:**
The study protocol was reviewed and approved by the Department of Community Health Sciences and then an approval was obtained from Research Ethics Committee at College of Applied Medical Science, King Saud University, Saudi Arabia.
A written consent was obtained from the parents or guardians of the CP children prior to the commencement of the study.

**Consent for publication:**
Not Applicable

**Availability of data and materials:**
The datasets generated during and/or analyzed during the current study are available in the Additional Files 1, 2 and 3.

**Competing Interest:**
None of the Authors have any competing interest

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Authors’ Contribution:

AA conceived the idea, developed design of study, and wrote the proposal for grant; ARA collected field data, IA and MA analyzed the data and wrote the first draft manuscript. SR, MFB, BAB and MA helped in the review of manuscript.

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Tables

Table 1: Demographic and Clinical characteristics of Cerebral Palsy Children (n=74)

| Characteristics                                      | Number n=74 | Malnourished n=41 (55.4%) | Normal Nutrition n=33 (54.6%) |
|-------------------------------------------------------|-------------|----------------------------|-------------------------------|
| Sex of child, N (%)                                   |             |                            |                               |
| Male                                                  | 44 (59)     | 23 (53)                    | 21                            |
| Female                                                | 30 (41)     | 18 (24)                    | 12                            |
| Age of Child, N (%)                                   |             |                            |                               |
| < 5 yrs                                               | 48 (65)     | 25 (34)                    | 23 (31)                       |
| > 5 yrs                                               | 26 (35)     | 17 (23)                    | 9 (12)                        |
| Severity of disease according to GMFCS levels, N(%)   |             |                            |                               |
| GMFCS level I-III                                     | 22 (30)     | 9 (12)                     | 13 (18)                       |
| GMFCS-II GMFCS level IV-V                             | 52 (70)     | 32 (43)                    | 20 (27)                       |
| Nutrient Intake, N(%)                                 |             |                            |                               |
| Adequate energy intake                                | 53 (72)     | 35 (47)                    | 18 (25)                       |
| Inadequate energy Intake                              | 21 (28)     | 6 (8)                      | 15 (20)                       |
| Adequate Protein intake                               | 49 (66)     | 32 (43)                    | 17 (23)                       |
| Inadequate protein intake                             | 25 (34)     | 9 (12)                     | 16 (23)                       |
|                          | Yes      | No       | Total (%) |
|--------------------------|----------|----------|-----------|
| Feeding problems of child| 57 (77)  | 32 (43)  | 57 (77)   |
|                          | 17 (23)  | 9 (12)   | 17 (23)   |
| Appetite of child        |          |          |           |
| Poor                     | 50 (68)  | 31 (42)  | 50 (68)   |
| Fair/Good                | 24 (32)  | 10 (14)  | 24 (32)   |
| Presence of Cognitive    |          |          |           |
| Impairment in child      | 54 (73)  | 35 (47)  | 54 (73)   |
|                          | 20 (27)  | 6 (8)    | 20 (27)   |
| Presence of anemia       |          |          |           |
| Yes                      | 32 (43)  | 23 (31)  | 32 (43)   |
| No                       | 42 (57)  | 18 (24)  | 42 (57)   |
| Creatinine               |          |          |           |
| N(%) within normal range | 56 (76)  | 30 (41)  | 56 (76)   |
| N(%) within abnormal     | 18 (24)  | 11 (15)  | 18 (24)   |
| range                    |          |          |           |
| Hematocrit               |          |          |           |
| N(%) within normal range | 49 (66)  | 21 (28)  | 49 (66)   |
| % within abnormal range  | 25 (34)  | 20 (27)  | 25 (34)   |
| Red Blood Cells          |          |          |           |
| N(%) within normal range | 52 (70)  | 23 (31)  | 52 (70)   |
| N() within abnormal range| 22 (30)  | 21 (29)  | 22 (30)   |

*GMFCS: Gross Motor Function Classification System*
Table 2: Anthropometric Characteristics of the Sample

| Nutritional Indices                  | N   | Mean  | SD   | Median |
|-------------------------------------|-----|-------|------|--------|
| Weight-for-age-z-score (WAZ)        | 74  | -1.73 | 1.02 | -1.65  |
| Height-for-age-z-score (HAZ)        | 74  | -1.30 | 1.06 | -1.19  |
| Weight-for-height-z-score (WHZ)     | 50  | -2.17 | 1.30 | -2.01  |
| BMI-for-age-z-score (BAZ)           | 74  | -1.68 | 1.36 | -1.54  |

Table 3: Classification of nutritional status according to body composition measurements

|                   | Malnutrition (%) | Normal Weight (%) |
|-------------------|------------------|-------------------|
| Arm Circumference (AC) | 13.5              | 86.5              |
| Arm Muscule Circumference (AMC) | 27.0              | 73.0              |
| Tricep Skifold Thickness (TST)      | 20.3              | 79.7              |

Table 4: Factors Associated with malnutrition
| Characteristics | Malnourished | Normal | OR               | p-value |
|-----------------|-------------|--------|------------------|---------|
| Age             |             |        |                  |         |
| >5 yrs; n=26    | 17          | 6      | 4.29 (1.46 to 12.58) | 0.046   |
| <5 yrs; n=48    | 24          | 24     | 1.00             |         |
| Gender          |             |        |                  |         |
| Male (n=44)     | 23          | 21     | 0.75 (0.29 to 1.87) | 0.532   |
| Female (n=30)   | 18          | 12     | 1.00             |         |
| Severity of the disease | | | | |
| GMFCS level I-III (n=22) | 9 | 13 | 0.43 (0.16 to 1.19) | 0.378 |
| GMFCS level IV-V (n=52) | 32 | 20 | 1.00 |         |
| Presence of cognitive impairment | | | | |
| Yes (n=54)     | 35          | 19     | 4.30 (1.42 to 13.02) | 0.032   |
| No (n=20)      | 6           | 14     | 1.00             |         |
| Anemia          |             |        |                  |         |
| Yes (n=32)     | 23          | 9      | 3.41 (1.28 to 9.12) | 0.026   |
| No (n=42)      | 18          | 24     | 1.00             |         |
| Feeding difficulties | | | | |
| Yes (n=57)     | 32          | 25     | 1.14 (0.38 to 3.38) | 0.293   |
| No (n=17)      | 9           | 8      | 1.00             |         |
| Appetite       |             |        |                  |         |
| Poor (n=50)    | 31          | 19     | 2.88 (0.85 to 6.15) | 0.093   |
| Fair/good (n=24) | 10         | 14     | 1.00             |         |
| Nulien intake  |             |        |                  |         |
| Inadequae energy (n=53) | 35 | 18 | 4.86 (1.61 to 14.66) | 0.043 |
| Adequae energy (n=21) | 6 | 15 | 1.00 |         |
| Inadequae proein (n=49) | 32 | 17 | 2.11 (0.80 to n5.53) | 0.063  |
| Adequae proein intake (n=25) | 9 | 16 | 1.00 |         |

Figures
Figure 1

Percent Distribution of Cerebral Palsy Children According to their Nutritional Status. WAZ: weight-for-age Z-score; HAZ: height-for-age Z-score; WHZ: weight-for-height Z-score; BAZ: BMI-for-age Z-score.

Figure 2

Venn Diagram showing the relationship between various nutritional indicators in the malnourished children. (A) underweight [weight-for-age z-score (WAZ)], thinness [BMI-for-age z-score (BAZ)], stunting [height-for-age z-score (HAZ)] in 2-12 year olds and (B) stunting [height-for-age z-score (HAZ)], wasting [weight-for-height z-score (WHZ)], and underweight [weight-for-age z-score (WAZ)] in 2-5 year olds. The overlap between the different indicators is illustrated. Regarding weight for age, the z-scores for 2 children were omitted because of outlier values. A further 2 children >10 years of age were not included in this calculation. Similarly, height-for-age Z-score and BMI-for-age z-score results for 1 child each were excluded from this calculation because of outlier values. Finally, with regard to weight-for-height z-score, only 74 children ≤5 years old were included in the calculation.

Figure 3

Percent of cerebral palsy children with adequate energy (white bar) and protein (grey bar) intake. Adequate energy and protein intake was determined using the Reference values of WHO.
Supplementary Files

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