J Nutr Health. 2021 Oct;54(5):474-488
https://doi.org/10.4163/jnh.2021.54.5.474
eISSN 2288-3959

JNH
Journal of Nutrition and Health

Research Article

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Nutritional status of children with cerebral palsy according to their body mass index percentile classification

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OPEN ACCESS

Received: Jul 17, 2021
Revised: Aug 27, 2021
Accepted: Oct 5, 2021

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Funding
This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2016R1D1A1B03935660).

ABSTRACT

Purpose: Malnutrition in children with cerebral palsy (CP) is a significant factor affecting their adequate growth and development. This study aimed at conducting surveys and evaluating the dietary intake of children with CP according to their BMI classification and to thereby highlight the dietary factors affecting the nutritional status of these children.
Methods: A total of 16 children were enrolled between the age of four and twelve. These subjects were further classified into three groups, namely underweight, normal and obese, with 6, 8, and 2 children in each group, respectively. The general characteristics, motor disturbances, body composition, feeding problems, eating habits, nutritional intake, dietary variety, and food frequency for children with CP were evaluated.
Results: It was observed that motor disturbances tended to increase in underweight children with CP. A significant decrease ($p < 0.05$) in disturbances related to oral feeding was observed with an increase in obesity. The pattern of eating habits revealed that subjects in the underweight group consumed unbalanced meals, while those in the obese group tended to consume larger meals at a faster pace. The feeding disturbance data revealed that those in the underweight group could not prepare their meals while the obese group had the problem of overeating and consuming an unbalanced diet ($p < 0.05$).
Conclusion: It is necessary for both children with CP, who have a high degree of disability, and their caregivers to take lessons on adequate nutrient intake to prevent malnutrition. Moreover, it is necessary for the caregivers and children with CP having a low degree of disability to take lessons on providing and consuming a balanced diet and to focus on the intake of sufficient calcium in order to prevent obesity.

Keywords: cerebral palsy, dietary intake, malnutrition

INTRODUCTION

Cerebral palsy (CP) is a series of permanent non-progressive disturbances that occurs in the developing fetus or infant brains causing abnormal motor or sensory functions [1,2]. Disturbances to the motor centers of the brain such as motor cortex, basal ganglia, brain stem, cerebellum or cerebral structures causes disorders of cognition, communications, behavior or perceptions, seizures and sensations [3,4]. An English orthopedic surgeon

Conflict of Interest
There are no financial or other issues that might lead to conflict of interest.

William little was the first person to coin the term "cerebral paralysis" about 170 years ago, by studying the correlation of a difficult labor and neonatal hypoxia with limb spasticity and musculoskeletal deformities [5]. Despite of advancement in medicines, the availability of neonatal intensive care units, high technology diagnostics and therapeutic methods, the incidence of CP has tended to increase due to increased survival rate of premature infants with neurological impairment. Depending upon various risk factors CP is estimated to be in range between 1.5 and 3.0 per 1,000 live births [6].

In previous times children having ataxic movements due to suffocation, that is movements due to muscle tensions, had been reported while recently increase in the number of children with low movement forms of CP due to contracture of rigid joints after premature birth have been reported to elevate [7]. Normal development of basic sensory and motor functions of the oral organs provides the basis of feeding ability that is polished and refined with growth during adulthood [8]. Moreover balanced food and nutrient intake is essential in early and late childhood to maintain normal growth and development of brain and body [9]. Therefore, disorders of feeding ability or disabilities of self-feeding adversely effects the adequate diet and nutrient intake in CP affected children. Among the physical characteristics of children with CP, eating disorders occurs in 68–94.5% of subjects due to abnormal muscle movements and delayed normal development while 3–10% of these subjects are on the verge of serious conditions. Eating disorders in children with CP appear according to the characteristics of children, but largely manifested disorders are of basic oral and physical function [10].

Children with CP, mainly with sensory impairment, have difficulties in recognizing oral sensations, because the threshold of oral stimulation is too low to clearly recognize stimuli in the mouth and tongue [11], this decrease in sensation is due to drooling in the form of aspiration pneumonia. In case of children with severe spastic CP difficulties in involuntary movements such as chewing and swallowing food are observed due to decreased oral muscle function and they also have sensory impairment due to drooling in the form of aspiration pneumonia. CP affected children with spastic paralysis of the arms and legs, finds it difficult to eat food on their own, such as to move hands and feet to pick up food with spoon [12,13]. These eating disorders can ultimately lead to poor growth due to malnutrition [13].

Environmental, cultural and social factors regulate ones food preferences and eating habits preferred to as ones dietary habits [14,15]. Dietary habits predicts ones nutritional and health status [16]. Inappropriate dietary habits affect normal growth and development. Consequently, it leads to adverse impacts on intellectual, social and economic life of an individual. Nutritional evaluation is necessary for management of health, malnutrition and obesity in CP affected children [17]. Accordingly, several previous studies tried to overcome this problem through evaluation according to various classification methods that appeared in children with CP, ranging from basic classification of CP to functional classification. CP functional disability categories are more informative for prognostic purposes than the clinical types. The most common etiological factors documented by radiological and pathological study are periventricular leukomalacia and middle cerebral artery infractions [18,19].

According to Rogozinski et al. [20], the prevalence of obesity in children with CP in US was 7.7% in 1994–1995 and it increased to 16.5% in 2003–2004 reporting that it has been doubled in the past 10 years. It has also been reported that the risk of obesity in CP affected children is higher than in general patients. According to their study, the prevalence of obese children

https://doi.org/10.4163/jnh.2021.54.5.474

with CP was observed to increase steadily for 10 years. According to Park et al. [21], the prevalence of CP was 2.6 per 1,000 children and the lifetime medical cost of its treatment in South Korea was $ 26,383 that is about 1.8 times higher than the medical cost of a general population. Of them, spastic CP had the highest medical cost, followed by dyskinetic and ataxic CP.

Inadequate food intake either leads to least amount of energy compared to the high demand of the body due to increased metabolism during growth or inadequate food intake causes less intake of nutrients than the recommended amount [22]. Poor growth and nutritional disorders are common comorbidities in CP subjects as reported in previous studies. According to a study conducted by Lopes et al. [23], out of 100 children with disabilities, 25%, 11% and 9% were underweight, mildly underweight and severely underweight respectively, suggesting that subjects with CP have nutritional abnormalities due to disabilities [24]. The percentages of characteristics mentioned were mainly based on having hemiplegia, diplegia and tetraplegia within the same ethnic group of Brazil. However, other study [25] has reported that Asians have a reduced risk CP compared with the Whites. The low risk profiles of CP in the Asian subgroups can be attributed to the maternal age, educational attainment and birth weight. After adjusting for these factors the risk of CP remained lower in the East Asians, Filipinos, Indians, Pacific Islanders and Southeast Asians compared with the Whites [25].

Matsuo and Palmer [26] together with Andrew et al. [27] highlighted the association between secondary disabilities and feeding problems. While there have been a volume of studies evaluating the dietary habits and food intake in children with disabilities, least information is available for disable subjects with CP.

Unlike most of other studies that focused on obesity in children, little information is available on nutritional status and obesity in CP affected children. Previous literature on CP subjects having physical disabilities in which food intake is not possible without assistance, general physical dysfunctioning and motor dysfuctioning shows malnutrition and compromised growth due to eating disorders and insufficient nutrient intake. Therefore, this study aimed at nutritional evaluation of children with CP having diverse phenotypes from underweight to obese subjects and consequently to design a personalized nutritional management plan for children with CP.

METHODS

Subjects and classification of group

Sixteen children with CP (13 boys and 3 girls) aged 4–12 years attending rehabilitation centers for the disabled and one daycare center in Changwon were enrolled in the study after agreement to the purpose of study. Study was conducted from January 5 to March 31, 2015. According to Korean children's and adolescent development standards, based on the body mass index (BMI) percentile, the underweight group was classified as percentile below 5th, the normal group with percentile above the 5th percentile and below the 95th percentile while the obese group with 95th or higher percentile. This study was conducted after obtaining approval from the Changwon National University Clinical Trial Committee (IRB No.1040271-201411-HR-016).

https://doi.org/10.4163/jnh.2021.54.5.474

General characteristics and degree of movement disorders survey

The general evaluation of the study subjects includes age, gender and degree of movement disorders. In order to find out the degree of disability in children with CP, primarily by referring to the existing research of Lopes et al. [23], that consisted of the Gross Motor Function Classification System (GMFCS) children were classified as stage I (walks without restrictions; limitations in more advanced gross motor skills), stage II (walks without assistive devices; limitations walking outdoors and in the community), stage III (walks with assistive mobility devices; limitations walking outdoors and in the community), stage IV (self-mobility with limitations; children are transported or use power mobility outdoors and in the community), stage V (self-mobility is severely limited even with the use of assistive technology). Moreover, the degree of disability was classified into mild (stage I and II), moderate (stage III) and severe (stage IV and V).

Anthropometric measurement and body composition analysis

In order to assess the anthropometric measurement of the study subjects, height and weight were measured directly using measuring tape and scale. In addition to determine the exact body composition evaluation was done using In body S10 (In body Co. Ltd., Seoul, Korea).

Eating disorders and eating habits survey

In order to investigate the eating disorders the study subjects, a questionnaire was prepared with reference to the existing study of Arvedson [28]. The contents of a set of 10 items to evaluate the physical and oral functions related to food intake. A Likert 5-point scale [29] was used to evaluate physical function, the lowest score assigned was 10 points and the highest score was 50 points, lower the score better was the eating function.

A questionnaire based on the work of Kim et al. [30] was developed to analyze the eating habits of the study subjects. The questionnaire was composed of a total 12 items to study the subject's general eating habits, eating attitudes, food preferences, problems with eating meals, and snack intake.

Nutrients intake analysis

The 24-hour recall method was conducted for a total of 3 days (including 2 weekdays and 1 weekend). As children with CP have difficulties in performing surveys and writing down the questionnaire on their own coupled with similar problems in eating and feeding themselves. A constant support is needed by these children in order to carry out their daily life activities like walking, cleaning and eating, etc. Therefore, they are provided with constant care and support by the parents or caregivers. Being their supervisors for every activity parents and caregivers can be a reliable source to obtain the information related to the CP subjects and hence the required information was collected from them. The type of the food, the amount of intake and variety of ingredients consumed were all recorded. For accurate investigation, ‘a flat model of food and its container’, which is the data provided by the National Health and Nutrition Survey of the Korea Health Industry Development Institute of the Ministry of Health and Welfare, and one-on-one interviews were conducted with guardians. Nutrient intake of study subjects was analyzed using a nutritional evaluation program (Computer Aided Nutritional Analysis for Professionals. Ver 5.0; Korean Nutrition Society, Seoul, Korea).

Food intake frequency analysis

In the case of food intake frequency survey, a preliminary survey was conducted on 3 children with CP using the food intake frequency table (2008) developed by the National Health and

https://doi.org/10.4163/jnh.2021.54.5.474

Nutrition Survey of the Ministry of Health and Welfare. Based on previous work done by Ahn [31], the survey was completed by modifying the foods with a high intake rate. According to the type of food group, the items of intake survey consisted of a total of 30 types of grains, fish, meat, vegetables, dairy, nuts, and fruits. The study subjects' food intake patterns were analyzed using a Likert 9-point scale.

Food intake patterns and dietary diversity score (DDS) analysis

Referring to the existing study of Kant and Graubard [32], the average number of food groups consumed in a day was evaluated through the DDS, which calculates each food group as 1 point. The lowest score was 0 points and the highest score was 6 points. Higher the score more balanced the dietary intake was.

Statistical analysis

Results analysis based on the collected data was applied as a statistical analysis method and statistical processing was analyzed using SPSS Statistics version 21.0 (IBM Corporation, New York, NY, USA). The general characteristics, eating habits, and intake patterns by food group were expressed as frequency and percentage, and differences according to the BMI percentiles of children with CP were post-tested by Duncan's multiple range test. In addition, the mean and standard deviation of physical characteristics, eating disorder, food diversity score, intake pattern by food, and nutrient intake were expressed as the BMI of children with CP. Differences according to percentiles were post-tested by Duncan's multiple range tests. Evaluation was performed using χ^2 test with utilization of Fisher's exact test. Statistical tests of all data processing and statistical analysis were verified at the significance level $p < 0.05$.

RESULTS

General characteristics and degree of movement disorders in children with CP

Among 16 children with CP, 66.7% (6 children) were assigned to the underweight group, 87.5% (8 children) to the normal group, and 100.0% (2 children) were in the obese group on the basis of their BMI percentiles (**Table 1**). Of these subjects there were 4 boys (66.7%) in the underweight group, 7 boys (87.5%) in the normal group and 2 boys (100.0%) in the obese group, showing a higher proportion of boys than girls in each group with no significant difference among the groups.

Table 1. General characteristics and degree of movement disorders in children with CP

Characteristics and movement disorders	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)	χ^2
Sex				1.504
Male	4 (66.7)	7 (87.5)	2 (100.0)	
Female	2 (33.3)	1 (12.5)	0 (0.0)	
Age (yrs)	7.33 ± 2.58	8.50 ± 1.60	8.00 ± 1.41	
GMFCS				2.667
Mild (stage I, II)	0 (0.0)	0 (0.0)	0 (0.0)	
Moderate (stage III)	2 (33.3)	4 (50.0)	2 (100.0)	
Severe (stage IV, V)	4 (66.7)	4 (50.0)	0 (0.0)	

Values are presented as number (%) or mean ± standard deviation. Data were analyzed using analysis of variance, and χ^2 test with utilization of Fisher's exact test.
CP, cerebral palsy; GMFCS, Gross Motor Function Classification System.

https://doi.org/10.4163/jnh.2021.54.5.474

Table 2. Anthropometric data and body composition in children with CP

Body Composition	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)
Weight (kg)	15.33 ± 5.91[a]	24.88 ± 4.16[b]	40.00 ± 2.83[c]
Height (cm)	108.92 ± 16.40[a]	122.00 ± 6.26[ab]	130.00 ± 0.00[b]
BMI (kg/m^2)	12.50 ± 1.05[a]	16.88 ± 1.25[b]	24.00 ± 1.41[c]
Weight percentile (%)	2.50 ± 3.67[a]	28.63 ± 21.15[b]	95.00 ± 7.07[c]
Height percentile (%)	3.17 ± 3.71[a]	23.75 ± 31.45[ab]	57.50 ± 45.96[b]
BMI percentile (%)	1.00 ± 0.00[a]	48.13 ± 18.31[b]	100.00 ± 0.00[c]
Fat (kg)	2.33 ± 2.25[a]	8.38 ± 2.67[b]	18.00 ± 2.83[c]
PBF (%)	12.50 ± 9.35[a]	32.13 ± 8.98[b]	44.50 ± 3.54[b]
FFM (kg)	13.00 ± 4.20[a]	16.75 ± 3.11[ab]	22.00 ± 0.00[b]
BMR (kcal)	651.83 ± 85.54[a]	733.75 ± 66.44[a]	850.50 ± 4.95[b]

Values are presented as mean ± standard deviation. Data were analyzed using analysis of variance followed by the Duncan's multiple range test.
CP, cerebral palsy; BMI, body mass index; PBF, percent body fat; FFM, fat free mass; BMR, basal metabolic rate.
[a,b,c]Values with different superscript letter are significantly different at $p < 0.05$.

In the degree of movement disorder divided by the GMFCS criteria, 66.7% (4 persons) of children were with severe movement disorders and 33.3% (2 persons) in the underweight group were found in the order of moderate movement disorder, and the normal group showed 50% (4 persons) of severe and 50% (4 persons) of moderately affected children. The 100% (2 persons) of children in the obese group were too moderately affected. As obesity increased, movement disorders tended to decrease, and there was no significant difference among the 3 groups.

Anthropometric data and body composition in children with CP

Table 2 shows the anthropometric data and body composition of subjects. Average weight percentile of underweight, normal, and obese children with CP were 2.5%, 28.6%, and 95.0%, respectively. Average BMI percentile of underweight, normal, and obese children with CP were 1.0%, 48.1%, and 100.0%, respectively.

Analyzing the body composition of the subjects, body fat content for the underweight group was found to be 2.33 ± 2.25 kg and 8.38 ± 2.25 kg for the normal group. In the case of the obese group, it was found to be 18.00 ± 2.83 kg, and the amount of body fat increased significantly ($p < 0.05$) as the degree of obesity increased. The body fat percentage was 12.50 ± 9.35% for the underweight group and 32.13 ± 8.98% for the normal group while in the case of the obese group it was found to be 44.50 ± 3.54% and it increased significantly with the increase in obesity level ($p < 0.05$). The lean mass for the underweight group was 13.00 ± 4.20 kg, 16.75 ± 3.11 kg for the normal group and 22.00 ± 0.00 kg in the obese group. Lean body mass also tended to increase with the increase in obesity ($p < 0.05$). The basal metabolic rate was 651.83 ± 85.54 kcal for the underweight group and 733.75 ± 66.44 kcal for the normal group while for the obese subjects it was found to be 850.50 ± 4.95 kcal. Similar increase in basal metabolic rate was found with the increase in obesity levels ($p < 0.05$).

Eating disorders in children with CP

The degree of impairment in physical function was 10.00 ± 4.00 in the underweight group, 8.00 ± 3.74 in the normal group and 2.93 ± 0.71 in the obese group (**Table 3**). The tendency of impairment in physical function relatively was found to increase in the underweight group but there was no significant difference among the 3 groups. The impairment score for oral functioning was 21.17 ± 6.49, 12.38 ± 4.44 and 10.50 ± 2.12 for the underweight, normal and obese group respectively. The degree of oral function impairment was found to be significantly higher in the underweight group ($p < 0.05$).

https://doi.org/10.4163/jnh.2021.54.5.474

Table 3. Eating disorders in children with CP

Eating Disorders	Underweight (n = 6)	Normal weight (n = 8)	Obesity (n = 2)
Dietary physical function[1)]			
Hard to sit alone	3.67 ± 2.07	2.00 ± 1.41	2.00 ± 1.41
Only breathe with mouth	1.83 ± 1.60	1.75 ± 1.16	1.50 ± 0.71
Not vomit it takes in the neck	1.50 ± 0.55	2.13 ± 1.36	1.50 ± 0.71
Shed the food at meal	3.00 ± 1.41	2.13 ± 1.13	2.50 ± 0.71
Sub total	10.00 ± 4.00	8.00 ± 3.74	2.93 ± 0.71
Oral dietary intake function[2)]			
The tongue moves freely	3.50 ± 0.84[a]	1.88 ± 1.13[a]	2.00 ± 0.00[ab]
The mouth moves freely	3.17 ± 0.75	1.88 ± 1.13	2.00 ± 0.00
Alone suck through a straw	3.50 ± 1.64	2.13 ± 1.36	1.50 ± 0.71
Alone drink from a cup	3.50 ± 1.76	2.13 ± 1.36	1.50 ± 0.71
Alone spoon up	4.17 ± 1.17[a]	2.75 ± 1.49[ab]	2.00 ± 0.00[b]
Chew the food alone	3.33 ± 1.63[a]	1.63 ± 0.52[ab]	1.50 ± 0.71[b]
Sub total	21.17 ± 6.49[a]	12.38 ± 4.44[b]	10.50 ± 2.12[b]
Total	31.17 ± 9.22[a]	20.38 ± 6.99[ab]	18.00 ± 1.41[b]

Values are presented as mean ± standard deviation. Data were analyzed using analysis of variance followed by the Duncan's multiple range test.
CP, cerebral palsy.
[1)]1 = strongly agree, 2 = agree, 3 = generally, 4 = disagree, 5 = strongly disagree. [2)]1 = strongly disagree, 2 = disagree, 3 = generally, 4 = agree, 5 = strongly agree.
[a,b]Values with different superscript letter are significantly different at $p < 0.05$.

General eating habits and eating attitudes in children with CP

In order to evaluate the average number of meals per day, when the frequency was '3 meals/day', the underweight group had a 66.7% (4 persons), the normal group had 100.0% (8 patients) and the obese group had 100.0% (2 patients) in total which was highest among the 3 groups, whereas the underweight group did not consumed a balanced diet while there was no significant differences (**Table 4**).

Table 4. General eating habits and eating attitude in children with CP

Eating Behaviour	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)	χ^2
Meal times				3.810
1 time/day	0 (0.0)	0 (0.0)	0 (0.0)	
2 times/day	2 (33.3)	0 (0.0)	0 (0.0)	
3 times/day	4 (66.7)	8 (100.0)	2 (100.0)	
Table time used				4.000
< 15 min	0 (0.0)	1 (12.5)	1 (50.0)	
15–30 min	3 (50.0)	4 (50.0)	1 (50.0)	
> 30 min	3 (50.0)	3 (37.5)	0 (0.0)	
Amount of intake				7.056
Little	2 (33.3)	1 (12.5)	0 (0.0)	
Normal	2 (33.3)	5 (62.5)	0 (0.0)	
A lot of	2 (33.3)	1 (12.5)	1 (50.0)	
Not adjustable	0 (0.0)	1 (12.5)	1 (50.0)	
Eating attitudes				5.500
Eat with words	2 (33.3)	3 (37.5)	1 (50.0)	
Normal	0 (0.0)	3 (37.5)	0 (0.0)	
Eaten quietly	2 (33.3)	1 (12.5)	1 (50.0)	
Moving and eat	2 (33.3))	1 (12.5)	0 (0.0)	
Feelings about the meal time				3.722
Delight	3 (50.0)	7 (87.5)	2 (100.0)	
Not appeal	1 (16.7)	0 (0.0)	0 (0.0)	
Boring	2 (33.3)	1 (12.5)	0 (0.0)	

Values are presented as number (%). Data were analyzed using χ^2 test with utilization of Fisher's exact test. There was no difference between the groups.
CP, cerebral palsy.

https://doi.org/10.4163/jnh.2021.54.5.474

In case of meal intake frequency, higher the degree of obesity, lower was the ability to control meals and there was frequent tendency to increase the amount of food intake, while there were no significant differences among the groups. In the question of attitude toward meal time, higher the obesity level, the more enjoyable meal time was and vice versa whereas there was no significant difference found.

Nutrients intake status in children with CP

In the case of average energy intake, the underweight group with lowest degree of obesity showed a tendency to have low energy intake and there were no significant differences found among the groups (**Table 5**). In the case of average protein intake, all 3 groups were consuming more than twice the average required amount with no significant differences. The average vitamin D intake was not significant in the underweight group than the required intake, and average calcium intake was also not significant in the normal and obese group. The average intake of vitamin B_{12} in all 3 groups was more than 4 times the sufficient intake and a significant difference ($p < 0.05$) was observed among the groups. In the case of average magnesium intake, it was found that all 3 groups had a lower intake than the recommended amounts (**Table 5**).

Food intake frequency in children with CP

Table 6 shows that noodles, bread, and pizza (grain intakes) by the normal group were consumed more than the other groups similarly for hamburger, sandwich and rice cake, the intake frequency of the normal group was significantly higher than that of the underweight group and obese group ($p < 0.05$). Whereas for cereal, the intake frequency tended to increase with the increase in obesity, while no significant difference among the groups was observed.

For meat group the intake of pork and fish, increased with the increase in obesity, whereas no significant difference was found among the groups. Among the vegetable group (salad, raw vegetables), intake frequency significantly increased as the obesity level increased ($p < 0.05$). Similarly, intake of namul, sam, and kimchi, also increased with increase in obesity level with no significant differences.

Table 5. Nutritional intakes status in children with CP

Nutritional intakes	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)
Energy EER %	84.31 ± 26.84	101.40 ± 24.17	92.49 ± 10.81
Protein EAR %	255.55 ± 138.43	264.12 ± 121.74	253.31 ± 79.42
Vitamin A EAR %	196.95 ± 107.04	201.48 ± 79.57	170.45 ± 25.93
Vitamin D AI %	66.82 ± 31.74	77.24 ± 22.50	102.02 ± 41.93
Vitamin C EAR %	225.79 ± 130.87	216.46 ± 156.46	235.17 ± 95.49
Niacin EAR %	154.38 ± 91.54	178.02 ± 95.66	155.99 ± 29.96
Vitamin B_6 EAR %	152.37 ± 58.34	154.56 ± 48.14	153.24 ± 33.07
Folate EAR %	170.67 ± 93.14	191.24 ± 74.73	205.30 ± 6.62
Vitamin B_{12} EAR %	402.26 ± 113.49[a]	390.13 ± 98.80[a]	633.71 ± 240.34[b]
Calcium EAR %	107.34 ± 35.10	87.60 ± 40.26	75.18 ± 25.82
Phosphorus EAR %	166.81 ± 67.52	153.69 ± 46.39	151.79 ± 53.38
Magnesium EAR %	59.08 ± 24.25	38.12 ± 11.35	48.32 ± 20.82
Zinc EAR %	175.51 ± 92.42	183.09 ± 92.20	169.55 ± 37.75

Values are presented as mean ± standard deviation. Data were analyzed using analysis of variance followed by the Duncan's multiple range test.
CP, cerebral palsy; EER, estimated energy requirements; EAR, estimated average requirements; AI, adequate intake.
[a,b]Values with different superscript letter are significantly different at $p < 0.05$.

https://doi.org/10.4163/jnh.2021.54.5.474

Table 6. Food consumption frequency in children with CP

Food Group	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)
Grains[1)]			
Bap	8.67 ± 0.52	8.88 ± 0.35	9.00 ± 0.00
Noodles	2.83 ± 2.23	4.13 ± 0.35	2.00 ± 1.41
Bread	3.00 ± 1.79	4.38 ± 1.77	2.50 ± 2.12
Pizza	1.67 ± 1.21	2.13 ± 1.13	1.00 ± 0.00
Hamburger, sandwich	1.17 ± 0.41[a]	2.50 ± 1.07[b]	1.00 ± 0.00[a]
Rice cake	1.83 ± 1.33[ab]	3.38 ± 1.60[b]	1.00 ± 0.00[a]
Cereal	1.83 ± 1.60	2.75 ± 1.98	4.00 ± 4.24
Meat, fish, eggs, etc.			
Bean curd	4.83 ± 1.17	6.25 ± 1.04	5.00 ± 0.00
Bean	3.33 ± 2.25	4.88 ± 2.70	4.50 ± 2.12
Eggs	5.00 ± 1.79	6.88 ± 1.81	5.50 ± 0.71
Pork	4.17 ± 1.47	4.88 ± 1.25	5.00 ± 0.00
Beef	3.17 ± 2.04	4.38 ± 2.20	4.00 ± 1.41
Chicken	4.00 ± 0.89	4.63 ± 1.41	3.50 ± 2.12
Fish	3.83 ± 0.98	4.50 ± 1.51	4.50 ± 0.71
Squid	1.50 ± 1.22	1.75 ± 1.49	1.00 ± 0.00
Vegetables			
Vegetables (seasoning)	5.67 ± 2.34	6.38 ± 1.30	7.00 ± 2.83
Vegetables (stir-fry)	4.67 ± 2.88	6.38 ± 1.69	5.50 ± 3.54
Vegetables (raw, salad)	2.00 ± 1.26[a]	3.50 ± 3.02[ab]	6.00 ± 1.41[b]
Sesame, pepper	1.17 ± 0.41	2.50 ± 1.85	4.00 ± 4.24
Cabbage kimchi	5.50 ± 2.81	6.25 ± 2.76	8.50 ± 0.71
Dairy			
Milk	6.33 ± 1.75	6.50 ± 2.51	7.00 ± 0.00
Liquid yoghurt	4.17 ± 1.83	5.38 ± 2.00	5.50 ± 0.71
Semisolid yoghurt	4.67 ± 2.34	5.88 ± 1.55	4.00 ± 1.41
Soymilk	3.17 ± 1.47	2.13 ± 2.23	3.00 ± 2.83
Cheese	3.33 ± 2.50	3.38 ± 2.72	3.00 ± 2.83
Nuts	1.33 ± 0.82	4.63 ± 3.07	2.00 ± 1.41
Fruit	6.83 ± 1.47	6.63 ± 1.19	7.00 ± 1.41

Values are presented as mean ± standard deviation. Data were analyzed using analysis of variance followed by the Duncan's multiple range test.
CP, cerebral palsy.
[1)]1 = hardly ever eating, 2 = 1 time/month, 3 = 2–3 times/month, 4 = 1 time/week, 5 = 2–4 times/week, 6 = 5–6 times/week, 7 = 1 time/day, 8 = 2 times/day, 9 = 3 times/day.
[a,b]Values with different superscript letter are significantly different at $p < 0.05$.

Table 7. Food intake patterns and DDS in children with CP

Food Intake and DDS	Underweight (n = 6)	Normal (n = 8)	Obesity (n = 2)	χ^2
GMVDNF[1)]				4.667
111101	5 (83.3)	2 (25.0)	1 (50.0)	
111111	1 (16.7)	6 (75.0)	1 (50.0)	
DDS[2)]	5.17 ± 0.41	5.75 ± 0.46	5.50 ± 0.71	4.667
5	5 (83.3)	2 (25.0)	1 (50.0)	
6	1 (16.7)	6 (75.0)	1 (50.0)	

Values are presented as number (%) and mean ± standard deviation. Data were analyzed using χ^2 test, ANOVA followed by the Duncan's multiple range test. There was no difference between the groups by χ^2 test, ANOVA test.
CP, cerebral palsy; ANOVA, analysis of variance; GMVDNF, grain, meat, vegetable, dairy, nut and fruit food group; DDS, dietary diversity score.
[1)]1 = present of each food group, 0 = absent of each food group. [2)]Counts the number of food groups (grain, meat, vegetable, dairy, nut and fruit) consumed.

Food intake patterns and DDS in children with CP

Subject's food intake pattern highlighted that nuts intake frequency was highest in the underweight group (**Table 7**). The DDSs out of 6 were 5.17 ± 0.41 for the underweight group, 5.75 ± 0.46 for the normal and 5.50 ± 0.71 for the obese group and there were no significant differences found among the groups.

https://doi.org/10.4163/jnh.2021.54.5.474

DISCUSSION

In this study in order to evaluate the physical characteristics, swallowing disorder, eating habits and meal intake of children with CP they were divided into underweight, normal and obese groups and the body composition, eating habits, and meal intakes were compared. A survey was composed and conducted in order to suggest a nutritional management plan for children with CP and to provide basic data for the prevention of nutritional and health disorders for these subjects.

On the basis of GMFCS classification the results of our study showed that the degree of movement impairments decreases with the increase in weight. In a study by Kim et al. [33], children with GMFCS levels 3 to 5 (in this study evaluated as moderate and severe motor impairment) showed a serious decline in social participation such as mobility, education, and social activities. It has been reported that the restriction of movements significantly affects social participation and activities of daily life.

The body composition of children with CP in our study showed that the basal metabolic rate, protein, fat, lean body fat, and body fat increased with increase in obesity, and there was no difference in body water content and minerals among the 3 groups. The body fat percentage was 13% in the underweight group, 32% in the normal, and about 45% in the obese group. This was similar to previous literature by Jeong et al. [34], who investigated the body fat percentage of children in the preschool years of Korea and reported body fat percentage of 16%, 22%, and about 31% in the normal, overweight, and obese group, respectively for boys whereas it was about 17%, 24%, and 31% in the normal, overweight, and obese group for girls, respectively.

According to a study by Kim et al. [35], it is reported that in order to maintain a healthy state, it is necessary to have a body fat mass of 10–25% for boys and 18–30% for girls. When body fat is insufficient, it causes various diseases such as adult disease, in particular. Therefore children with CP should be aware of the increased risk of exposure to various diseases due to neurological disorders and eating disorders caused by lack of body fat [36].

In addition, Kim et al. [35] reports that children with disabilities have a higher degree of obesity than children without disabilities, which increases the risk of nutritional disorders in these subjects. In this study, the degree of eating disorder in children with CP was found to be higher in the underweight subjects and it was difficult for them to consume food on their own, so the help of parents and teachers was required. In a study by Yoon and Choi [37], children with spastic CP had mastication problems due to lack of trunk stability and abnormal muscle tone. These subjects had lower ability to use spoon for eating and cup for drinking purposes compared with other children.

Looking at the eating habits of children with CP in this study, it was observed that number and intake meals tends to be less balanced in the underweight group while the time required to eat decreased with the increase in obesity. For the underweight group meal intake was less, adequate for normal and high in case of the obese group. Subjects of underweight group had higher intake of snacks in order to fulfill their energy needs. Moreover, the degree of disability decreased with increase in obesity but it was difficult for subjects in this group to control their food intake. In the study of Ahn [31], it was reported that children with disabilities generally have difficulty in controlling their meal intake and that their intake is high thus increasing the risk of obesity.

https://doi.org/10.4163/jnh.2021.54.5.474

One of the important factor that was emphasized by all the 3 groups was the taste of the food, similar to the analysis reported by Yoon and Choi's study [37] in which the disabled children had a keen interest in the tasting, color and texture of food. In this study the nutritional requirements for the underweight group needed special attention in order to gain weight by making special dietary choices monitored and provided by the parents and caregivers of these subjects. In addition, the normal group in our study tended to pay special attention to smell of food unlike other groups.

Looking at the problems of eating habits in this study, the underweight group complained of 'cannot eat on their own' or 'refusal to eat', normal group subjects of 'cannot eat by themselves' and in case of obese groups 'overeating' was the main problem that increased the level of obesity. Although with this increase in obesity the cause of spastic CP, which makes it difficult to eat by own decreases but leads to inability of controlling the amount of food intake [38]. Irregular diet intake was high in the underweight group, lack of appetite, in the normal and obese group tended to eat regularly. In the case of the underweight group, the growth and development was slow due to decreased food intake because of low appetite [39].

Looking at snack intake in this study, the number of snack intakes tends to be higher in the underweight group. In addition, unlike in the normal and obese group, where most of them ate snacks for reason of 'wanting to eat (appetite)' and 'hungry', subjects of underweight group consumed snacks because they want to fulfill their nutritional requirements.

For the nutrient intake of study subjects the underweight group had low energy intake than normal and obese groups. A study by Kim et al. [40] reported that the caloric intake rate of children with CP was below the standard requirement. The average intake of vitamin D in this study was found to insignificant in the underweight and the normal group.

It was observed that obese group had sufficient intake and with the increase in obesity higher was the vitamin D intake. Whereas in a study by Park et al. [39], the intake of vitamin D was reported to be less than 50% of the recommended intake by disable subjects. In the case of average calcium intake, underweight group had sufficient intake while normal and obese groups were found to have insignificant intakes than the standard requirements. Moreover, with the increase in obesity level intake of calcium tended to decrease. Kim et al. [40] reported that the calcium intake of children with disabilities did not reach the recommended amount. Therefore, as this study shows in case of nutritional recommendations for children with CP, the intake of calories and vitamin D should be emphasized and maintained for the underweight group, while it is necessary to maintain standard calcium intake in the obese group. In the case of average magnesium intake, it was found that all 3 groups had a lower intake than the recommended amounts (110 mg/day for 4–8 years old children while 350 mg/day for children age 9 and up). Magnesium has been considered to help in alleviating muscle spasticity and constipation in CP affected children. Due to compromised diet in CP affected children, the levels of magnesium declines, and hence leads to worsening of disorders. Many studies previously have evaluated the beneficial effects of magnesium sulphate supplementation as a muscle relaxant either via oral or intravenous route. It causes pre-synaptic effect through the inhibition of acetylcholine that is released at the motor nerve terminals while some studies reported that increased concentrations of extracellular magnesium reduces acetylcholine evoked responses in mouse [41]. Adequate levels of magnesium given intravenously reduced painful leg cramps [42] and rigidity of muscle spasm in tetanus patients [43]. Therefore, its low levels can thus be associated with increased muscle spasticity in children with CP.

https://doi.org/10.4163/jnh.2021.54.5.474

As a limitation of this study, since it was conducted in a limited area targeting children at welfare centers in Changwon, there is a limitation in representing all children with CP in Korea. The sample size of our study was small however it can be related in accordance with many previously reported literatures [44-48] that by utilizing the same sample sizes have been able to present fruitful results. These studies have reported and analyzed the level of malnutrition, gastrointestinal disorders, growth, feeding and nutritional disorders in children by including a limited number of subjects that were affected by CP. Therefore, for a broader investigation, a study on children with CP across the country should be conducted. In addition, the limitations of the questionnaire survey included the limited varieties of food, assistance requirement for filling out the questionnaire, and in-depth interviews survey conduction was required to diversify the dietary life of children with CP. According to the results of this study, underweight children with CP have a very high degree of disability, so they consume less food. Since it is difficult to consume foods by their own, the role of parents and teachers is important. This study suggests that active nutrition education, for parents and teachers who are highly involved in the diet management of children with CP, is necessary in developing nutritional management plan for these children.

In addition, in the case of obese children with CP, it is very important to control their eating habits because they tend to eat faster and had less control over their food intake. To develop nutritional management plan for children with CP, it is important to conduct investigations on movement disorders, eating disorders, and obesity. Emphasis on the risk of malnutrition in case of the underweight subjects is required while for the obese group overeating and unbalanced diet intake should be focused in order to develop individually tailored nutritional treatment for these subjects.

SUMMARY

In summary, this study was designed to help develop individually tailored nutritional management plan to promote healthy and desirable dietary habits for children affected with CP living in Changwon, South Korea, by analyzing their physical characteristics, dietary intake, swallowing disorders, eating habits, and meal intake. It was concluded that the degree of disability increased in underweight subjects due to improper meals and low energy intake, causing an increased risk of malnutrition in these children. This study shows that in the case of nutritional recommendations for children with CP, the intake of calories and vitamin D should be emphasized and maintained for the underweight group, while it is necessary to maintain standard calcium intake in the obese group. Moreover, negative dietary habits were also observed in obese children with CP, where overeating was the main concern; however, the degree of disability was found to decrease in obese children compared to underweight children. This suggests that the disability problem and worsening of this can be prevented by proper meal and nutrient intake for underweight children. Our study results could be used to promote healthy eating and dietary habits in affected children by emphasizing the risk of malnutrition, overeating, and unbalanced diet intake to develop individually tailored nutritional treatments. According to the results of this study, underweight children with CP have a very high degree of disability, so they consume less food. Therefore, the role of parents and teachers is important to help maintain nutritional balance and a healthy lifestyle. This study suggests that active nutrition education for parents and teachers who are highly involved in the diet management of children with CP is required, and it is necessary to develop nutrient management plans for children with CP. The findings

https://doi.org/10.4163/jnh.2021.54.5.474

of this study will contribute to the development of dietary strategies to help maintain a healthy state in CP-affected children living in South Korea.

REFERENCES

1. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007; 109: 8-14.
PUBMED
2. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, et al. Proposed definition and classification of cerebral palsy, April 2005. Dev Med Child Neurol 2005; 47(8): 571-576.
PUBMED | CROSSREF
3. Monbaliu E, Himmelmann K, Lin JP, Ortibus E, Bonouvrié L, Feys H, et al. Clinical presentation and management of dyskinetic cerebral palsy. Lancet Neurol 2017; 16(9): 741-749.
PUBMED | CROSSREF
4. Gulati S, Sondhi V. Cerebral palsy: an overview. Indian J Pediatr 2018; 85(11): 1006-1016.
PUBMED | CROSSREF
5. Vykuntaraju K. Cerebral palsy and early stimulation. New Delhi: Jaypee Brothers Medical Publishers Private Ltd.; 2014.
6. Maenner MJ, Blumberg SJ, Kogan MD, Christensen D, Yeargin-Allsopp M, Schieve LA. Prevalence of cerebral palsy and intellectual disability among children identified in two U.S. National Surveys, 2011-2013. Ann Epidemiol 2016; 26(3): 222-226.
PUBMED | CROSSREF
7. Krigger KW. Cerebral palsy: an overview. Am Fam Physician 2006.73(1): 91-100.
PUBMED
8. Soliman A, De Sanctis V, Elalaily R. Nutrition and pubertal development. Indian J Endocrinol Metab 2014; 18(Suppl 1): S39-S47.
PUBMED | CROSSREF
9. Aisen ML, Kerkovich D, Mast J, Mulroy S, Wren TA, Kay RM, et al. Cerebral palsy: clinical care and neurological rehabilitation. Lancet Neurol 2011; 10(9): 844-852.
PUBMED | CROSSREF
10. Morris SE. Development of oral-motor skills in the neurologically impaired child receiving non-oral feedings. Dysphagia 1989; 3(3): 135-154.
PUBMED | CROSSREF
11. Miller F, Bachrach SJ. Cerebral palsy: a complete guide for caregiving. Baltimore (MD): Johns Hopkins University Press; 2017.
12. Kurtz LA. Understanding motor skills in children with dyspraxia, ADHD, autism, and other learning disabilities: a guide to improving coordination. London: Jessica Kingsley Publishers Ltd.; 2007.
13. Almuneef AR, Almajwal A, Alam I, Abulmeaty M, Al Bader B, Badr MF, et al. Malnutrition is common in children with cerebral palsy in Saudi Arabia–a cross-sectional clinical observational study. BMC Neurol 2019; 19(1): 1.
PUBMED | CROSSREF
14. Birch LL. Development of food preferences. Annu Rev Nutr 1999; 19(1): 41-62.
PUBMED | CROSSREF
15. Fischler C. Food habits, social change and the nature/culture dilemma. Soc Sci Inf (Paris) 1980; 19(6): 937-953.
CROSSREF
16. Deshpande S, Basil MD, Basil DZ. Factors influencing healthy eating habits among college students: an application of the health belief model. Health Mark Q 2009; 26(2): 145-164.
PUBMED | CROSSREF
17. Melunovic M, Hadzagic-Catibusic F, Bilalovic V, Rahmanovic S, Dizdar S. Anthropometric parameters of nutritional status in children with cerebral palsy. Mater Sociomed 2017; 29(1): 68-72.
PUBMED | CROSSREF
18. Wiklund LM, Uvebrant P. Hemiplegic cerebral palsy: correlation between CT morphology and clinical findings. Dev Med Child Neurol 1991; 33(6): 512-523.
PUBMED | CROSSREF

19. Humphreys P, Deonandan R, Whiting S, Barrowman N, Matzinger MA, Briggs V, et al. Factors associated with epilepsy in children with periventricular leukomalacia. J Child Neurol 2007; 22(5): 598-605.
PUBMED | CROSSREF

20. Rogozinski BM, Davids JR, Davis RB, Christopher LM, Anderson JP, Jameson GG, et al. Prevalence of obesity in ambulatory children with cerebral palsy. J Bone Joint Surg Am 2007; 89(11): 2421-2426.
PUBMED | CROSSREF

21. Park MS, Kim SJ, Chung CY, Kwon DG, Choi IH, Lee KM. Prevalence and lifetime healthcare cost of cerebral palsy in South Korea. Health Policy 2011; 100(2-3): 234-238.
PUBMED | CROSSREF

22. Wiskin AE, Davies JH, Wootton SA, Beattie RM. Energy expenditure, nutrition and growth. Arch Dis Child 2011; 96(6): 567-572.
PUBMED | CROSSREF

23. Lopes PA, Amancio OM, Araújo RF, Vitalle MS, Braga JA. Food pattern and nutritional status of children with cerebral palsy. Rev Paul Pediatr 2013; 31(3): 344-349.
PUBMED | CROSSREF

24. Fung EB, Samson-Fang L, Stallings VA, Conaway M, Liptak G, Henderson RC, et al. Feeding dysfunction is associated with poor growth and health status in children with cerebral palsy. J Am Diet Assoc 2002; 102(3): 361-373.
PUBMED | CROSSREF

25. Lang TC, Fuentes-Afflick E, Gilbert WM, Newman TB, Xing G, Wu YW. Cerebral palsy among Asian ethnic subgroups. Pediatrics 2012; 129(4): e992-e998.
PUBMED | CROSSREF

26. Matsuo K, Palmer JB. Anatomy and physiology of feeding and swallowing: normal and abnormal. Phys Med Rehabil Clin N Am 2008; 19(4): 691-707.
PUBMED | CROSSREF

27. Andrew MJ, Parr JR, Sullivan PB. Feeding difficulties in children with cerebral palsy. Arch Dis Child Educ Pract Ed 2012; 97(6): 222-229.
PUBMED | CROSSREF

28. Arvedson JC. Assessment of pediatric dysphagia and feeding disorders: clinical and instrumental approaches. Dev Disabil Res Rev 2008; 14(2): 118-127.
PUBMED | CROSSREF

29. Bertram D. Likert scales [Internet]. Calgary: University of Calgary; 2007 [cited Nov 2]. Available from: http://pages.cpsc.ucalgary.ca/~saul/wiki/uploads/CPSC681/topic-dane-likert.pdf.

30. Kim KN, Kim AJ, Park ES, Woo MK, Lee BK, Hyun T. Content analysis of the questionnaires used in dietary surveys. Korean J Community Nutr 2000; 5(4): 697-708.

31. Ahn S. Comparison of food habits, food behaviors and food preferences in disabled children and non-disabled children [dissertation]. Gangneung: Gangneung National University; 2003.

32. Kant AK, Graubard BI. Energy density of diets reported by American adults: association with food group intake, nutrient intake, and body weight. Int J Obes 2005; 29(8): 950-956.
PUBMED | CROSSREF

33. Kim HH, Park ES, Park JE, Lee HJ, Nam JM, Choi MS, et al. Do gross/fine motor functions and/or non-speech mechanism function affect feeding-swallowing function in children with cerebral palsy? Commun Sci Disord 2008; 13(2): 242-262.

34. Jeong MJ, Yun YJ, Kim BH, Kim KB. Percentile of body fat percentage for diagnose obese among selected number of preschool children in Yangsan. J Pediatr Korean Med 2011; 25(1): 82-89.
CROSSREF

35. Kim SH, Ahn JB, Lee OB, Kwon DH. Differences on articulators' function according to feeding subtypes between children with spastic cerebral palsy and normal children. Phon Speech Sci 2010; 2(2): 93-100.

36. Huysentruyt K, Geeraert F, Allemon H, Prinzie P, Roelants M, Ortibus E, et al. Nutritional red flags in children with cerebral palsy. Clin Nutr 2020; 39(2): 548-553.
PUBMED | CROSSREF

37. Yoon MA, Choi YS. A study on dietary behavior and nutrient intake of children with developmental disorders in Gyeongbuk area. Korean J Nutr 2012; 45(1): 44-56.
CROSSREF

38. Chung YS, Han BM. Impact of eating habits and food preferences on adoptive behavior of children with intellectual disabilities. Korean J Food Cult 2012; 27(5): 459-468.
CROSSREF

39. Park EJ, Moon HK, Lee SS, Park WH. A study on the food habit and nutritional status of developmentally disabled children. Korean J Nutr 2001; 34(2): 188-197.

40. Kim JD, Bae YK, Cho MS. Eating patterns of children with cerebral palsy by table utensil-handling skills. J Korean Diet Assoc 2009; 15(2): 139-151.
41. Wang H, Liang QS, Cheng LR, Li XH, Fu W, Dai WT, et al. Magnesium sulfate enhances non-depolarizing muscle relaxant vecuronium action at adult muscle-type nicotinic acetylcholine receptor in vitro. Acta Pharmacol Sin 2011; 32(12): 1454-1459.
PUBMED | CROSSREF
42. Diener HC, Westphal K. Differential diagnosis and treatment of cramps. MMW Fortschr Med 2013; 155 Suppl 3: 83-86.
PUBMED | CROSSREF
43. Mathew PJ, Samra T, Wig J. Magnesium sulphate for treatment of tetanus in adults. Anaesth Intensive Care 2010; 38(1): 185-189.
PUBMED | CROSSREF
44. Thomas SS, Buckon CE, Schwartz MH, Russman BS, Sussman MD, Aiona MD. Variability and minimum detectable change for walking energy efficiency variables in children with cerebral palsy. Dev Med Child Neurol 2009; 51(8): 615-621.
PUBMED | CROSSREF
45. Stuberg WA, Fuchs RH, Miedaner JA. Reliability of goniometric measurements of children with cerebral palsy. Dev Med Child Neurol 1988; 30(5): 657-666.
PUBMED | CROSSREF
46. Reddihough D, Johnson H, Staples M, Hudson I, Exarchos H. Use of benzhexol hydrochloride to control drooling of children with cerebral palsy. Dev Med Child Neurol 1990; 32(11): 985-989.
PUBMED | CROSSREF
47. Campanozzi A, Capano G, Miele E, Romano A, Scuccimarra G, Del Giudice E, et al. Impact of malnutrition on gastrointestinal disorders and gross motor abilities in children with cerebral palsy. Brain Dev 2007; 29(1): 25-29.
PUBMED | CROSSREF
48. Stevenson RD, Roberts CD, Vogtle L. The effects of non-nutritional factors on growth in cerebral palsy. Dev Med Child Neurol 1995; 37(2): 124-130.
PUBMED | CROSSREF