Review Article

Nutritional status and growth in children with cerebral palsy: a review

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Abstract

The objective of this work was to review the studies conducted among developing and developed countries to assess the growth pattern and nutritional status of children with cerebral palsy. It also aimed at summarizing the key factors responsible for high prevalence of undernutrition among them. Significant reductions in the anthropometric parameters were found in children with cerebral palsy as compared to their nondisabled counterparts. This deviation from normal growth can be attributed to inadequate dietary intake, feeding problems, decreased weight bearing, and several non-nutritional factors including abnormal endocrine function, socioeconomic status, disease severity, and age. Also, it was seen that undernutrition was more prevalent among developing countries as compared to developed countries. Besides undernutrition, various studies conducted among developed countries have reported a high prevalence of overweight and obesity among this population. This could be attributed to a decrease in the motor function because of the underlying condition and an increase in the gastrostomy feeding owing to availability of better health care facilities.

KEY WORDS: Cerebral palsy, growth, malnutrition, feeding

Introduction

Growth pattern in children with cerebral palsy (CP) differs from children in the general population.[1–5] Children with CP have the linear growth,[6,7] weight,[6] muscle mass,[6] fat stores,[6] and bone mass density[8] below average as compared to the general population. Besides undernutrition, overweight and obesity have also been reported among these children.[9–11] Deviation from normal growth can be attributed to malnutrition, feeding problems,[12,13] abnormal endocrine function, decreased weight bearing, disease severity,[14] age, and gender. Socioeconomic status and provision of good health care facilities also play a key role.

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Growth pattern in children with CP

Cerebral palsy is a disorder of posture and movement.[15] These children grow poorly throughout their lives.[2,16,17] They have significantly lower mean height,[18–20] weight,[7,18–20] skinfold thickness,[7,19] and mid upper arm circumference (MUAC)[7,18] as compared to general population. Community-based cross-sectional surveys in Philippines,[21] Nigeria,[22] Bangladesh,[15] and India[19] have also reported similar findings [Table 1].

Overweight and obesity have also been reported by various researches conducted mostly in developed countries [Table 2]. Prevalence of overweight found to vary from 2% in Nigeria[18] to 16% in Norway.[9] Overweight and obesity are more prevalent among spastic bilateral CP than spastic unilateral CP.[9] This could be because children with spastic unilateral CP are more mobile as compared to those with spastic bilateral CP, and they have less feeding problems due to which they have a greater chance of gaining weight.

Table 1: Comparison of nutritional status of CP children in developed and developing countries

Study	Country	Sample description	Growth standards used	Prevalence of underweight (%)	Prevalence of wasting (%)	Prevalence of stunting (%)
Developed countries						
Dahlseng et al.[9]	Norway	Sample size: 661 Age: mean (6.7±1.5) Type of CP: all	Norwegian growth curves	20% below –2 SD	7% BMI <16	20% below –2 SD
Karagiozoglou-Lampoudi et al.[10]	2 Greek cities	Sample size: 42 Age: 2–15 years Type of CP: All	NCHS standards	38% below – 2 SD	–	–
Samson-Fang et al.[23]	6 Sites in North America	Sample size = 235 Age: 2–18 years Type of CP: All Severity: Moderate to Severe only	NCHS standards	47% weight <5th percentile for their age and gender	–	68% less than 2.5th percentile for age and gender
Hung et al.[11]	Taiwan	Sample size: 75 Age: 5 months to 10 years Type of CP: All	NCHS standards	47% below 10th percentile	41% below 10th percentile	36% below 10th percentile
Vik et al.[24]	Norway	Sample size: 259 Age: 3–19 years Type of CP: All	Norwegian growth curves	–	10% below 2.5th percentile	30% below 2.5th percentile
Krick et al.[25]	North America	Sample size: 360 children Age: 0–10 years Type of CP: quadriplegia only	NCHS standards	47% below 10th percentile	–	–
Stallings et al.[36]	North America	Sample size: 154 Age: 2–18 years Type of CP: diplegia and hemiplegia	NCHS standards	29% below –2 SD	–	23% below –2 SD
Developing countries						
Adams et al.[27]	Bangladesh	Sample size: 37 Age: 1–11 years Type of CP: all Severity of CP: moderate and severe only	WHO growth standards (2006)	Mean: –4.83±1.84	–	Mean: –2.70±1.98
Okeke and Ojinnaka[18]	Nigeria	Sample size: 98 Age: 8 months to 5 years Type of CP: all	NCHS standards	36% were malnourished	16.3% (by Wellcome Classification)	9.3% (by Wellcome Classification)
Caram et al.[16]	Brazil	Sample size: 114 Age: 2–12 years Type of CP: all	–	51% were below –2 SD	–	39% were below –2 SD
Sjakti et al.[26]	Indonesia	Sample size: 55 Age: 1–10 years Type of CP: all	NCHS standards	–	66% were undernourished and 11% were severely malnourished (by Waterlow classification)	–
Ozturk et al.[28]	Turkey	Sample size: 43 Age: 1–16 years Type of CP: all	NCHS standards	35% were below –2 SD	9% were below –2 SD	30% were below –2 SD
Gangil et al.[29]	India	Sample size: 100 Age: 1–12 years Type of CP: all	–	–	86% were malnourished	–
Zainah et al.[7]	Malaysia (urban community only)	Sample size: 101 Age: 2–12 years Type of CP: all	Age- and gender-specific reference data derived from another study	78% were <5th percentile	–	–

BMI, body mass index; SD, standard deviation; NCHS, National Center for Health and Statistics; WHO, World Health Organization

Table 2: Prevalence of obesity among children with CP

Study	Country	Description of sample	Growth standards used	Prevalence of obesity (%)
Developed countries				
Karagiozoglou-Lampoudi et al.[10]	2 Greek cities	Sample size: 42 Age: 2–15 years Type of CP: all	WHO and NCHS standards	7% over +2 SD
Stallings et al.[36]	North America	Sample size: 154 Age: 2–18 years Type of CP: diplegia and hemiplegia	–	14% over +2 SD
Krick et al.[25]	North America	Sample size: 360 children Age: 0–10 years Type of CP: quadriplegia	Center for Disease Control and Prevention	8% above 90th percentile
Hung et al.[11]	Taiwan	Sample size: 75 Age: 5 months to 10 years Type of CP: all	NCHS standards	4% above 90th percentile
Dahlseng et al.[9]	Norway	Sample size: 661 Age: mean (6.7±1.5) Type of CP: all	Norwegian growth curves	16% had BMI >25 (overweight + obese)
Vik et al.[24]	Norway	Sample size: 259 Age: 3–19 years Type of CP: all	Norwegian growth curves	7% above 97.5 percentile
Developing country				
Okeke and Ojinnaka[18]	Nigeria	Sample size: 98 Age: 8 months to 5 years Type of CP: all	NCHS standards	2% (by Wellcome classification)

WHO, World Health Organization; NCHS, National Center for Health and Statistics; SD, standard deviation; BMI, body mass index

Factors responsible for undernutrition and poor growth

Various factors such as nutritional, physical, and factors related to the brain lesion have been related with poor growth among this population. Nutritional factors such as poor dietary intake, oral motor impairments, swallowing incompetence, and poor nutritional status can have a direct impact on growth.[30,31] Physical factors such as decreased mechanical stress on bones due to immobility or lack of weight bearing may suppress certain growth-stimulating hormones, resulting in decreased bone formation and decreased longitudinal growth.[32] Growth may be affected due to brain lesions either directly through negative neurotrophic effect or indirectly through endocrine system.[33] Along with these factors, psychosocial effects are also responsible for growth faltering.[34] All these factors act synergistically to affect growth in every dimension among this population.[35]

I. *Malnutrition and Feeding Problems*

Impaired nutritional status is a prime contributor to poor growth.[5,32,35,36] Malnutrition occurs when a child is unable to meet his/her requirements of vital nutrients. This could be due to difficulty in feeding or scarcity, or when the needs exceed from what they can consume.[11,26,35,37] Feeding difficulty among CP children has been identified as one of the main contributing factor to undernutrition.[6,38,39] It impairs the child's ability to safely consume calories and nutrients necessary to support growth.[9,32,40,41] Weight *z*-scores have been found to be a major correlate of growth among 171 children with CP in a study.[26] It can have a negative impact on child's respiratory health, gastrointestinal functioning, and parent–child relation.[37] It may also hamper the child's cognitive, emotional, and physical developments.[42]

Some of the common feeding problems among them include difficulties with self-feeding, chewing, and swallowing.[43,44] Other problems include food refusal, lack of initiation to take food offered, problems with biting and sucking, drooling, food/fluid loss during feeding, and sequencing and rhythmicity difficulties.[45]

Children without feeding problems have better mean *z*-scores for weight,[9,46] height,[9] body mass index (BMI),[9] triceps or subscapular skinfold,[46] and MUAC.[46] Also, those with more than one feeding problem are at a higher risk of undernutrition than children who with none or just one feeding problem.[11,26] Improving the child's feeding ability can lead to an improvement in their nutritional status, especially BMI *z*-scores.[10] Further, severity of the feeding problems also has a negative effect on the nutritional status of children with spastic CP.[11] Those with severe feeding problems tend to have lower weight,[6,24,25] height, mid-arm muscle area, and skinfold thickness.[6] Even those with mild feeding dysfunction are at high risk of it.[6]

II. *Quantitative Inadequacies in Diets*

Quantitative "inadequacy" rather than qualitative "adequacy" in diet is responsible for poor growth among these children.[36,37,40] Among high-income countries, low energy intake was identified as a major cause of nutritional deficit.[36,40] Among low-income countries, consequent micronutrient deficiencies further had a negative impact on the child's nutritional status and health.[19] Approximately 80% of the children with CP in developing countries are not receiving adequate calories in their diet.[16,29,40] Various factors such as miscommunication, feeding impairment, neurological maturation, motor impairment, and medication side effects are responsible for poor dietary intake among them.[6] Inadequate intake and inappropriate food choices can be modified, together with self-feeding impairment, which can help in improving their nutritional status.[10,47]

It has also been hypothesized that children with CP have increased metabolic needs due to hypertonia or movement disorders. It was speculated that a decrease in spasticity led to a decrease in energy expenditure, which was responsible for growth improvement.[48] Another theory suggests that children with CP have decreased metabolic needs as a result of low resting energy expenditure.[17,36,49,50] In children with spastic quadriplegic CP, low non-basal energy expenditure and an inadequate food intake rather than higher metabolic need were found to be responsible for malnutrition. It was also observed that those children who had low fat stores had even lower resting energy expenditure, most likely due to a metabolic adaptation to chronic malnutrition.[36]

But some children receiving adequate calories are also found to be malnourished. This suggests that there are other factors such as gastroesophageal reflux, chronic diseases, visual or hearing impairments, constipation, and stressful feeding sessions contributing to malnutrition among them.[16]

III. *Growth Hormone Deficiency*

Growth hormone (GH) is essential for normal growth.[51] Children with CP have a short stature, which declines progressively from birth to puberty.[25,33,52–54] Several studies have reported abnormalities in secretion of GH among 60%–100% children in this population.[52,54,55] Kuperminc et al.[53] showed that children with CP grew more slowly than those without CP ($p < 0.01$), and the differences in both the groups could be attributed to diminished circulating insulin-like growth factor 1 and GH concentrations.

Stevenson et al.[34] reported a linear growth rate decline (with age) among 171 children with CP, attending an outpatient clinic in a tertiary-care setting. This decline in their linear growth was independent of their nutritional status.[34] It has also been seen that pubertal growth spurt is hampered in children with moderate CP.[1,2]

Some of the possible mechanisms behind GH deficiency are anatomic abnormalities of the hypothalamic–pituitary axis,[54,55] psychosocial deprivation,[55] and an interaction between suboptimal nutritional status and an abnormal central nervous system.[53,55] Severe brain damage may also affect a number of neurotransmitter pathways involved in GH control, thus affecting the normal secretion of the hormone.[52] Gross Motor Function Classification System (GMFCS) and severity of spasticity have also been found to have a negative impact on GH and insulin-like growth factor 1.[56] GH replacement therapy among these children can help them in achieving a normal height and allow for correction of some of the common disabilities experienced by them.[52–54,56]

IV. *Functional Status and Disease Severity*

Nonnutritional factors such as severity of disease, functional capability of children, negative neurotrophic growth effects, psychosocial influences, lack of weight bearing, ambulation, poor communication ability, and dependence on caretaker for feeding have been associated with undernutrition.[30] Two studies[34,57] conducted on children with hemiplegic CP (having normal nutritional status and normal stature) reported that all the measures of breadth, circumference, and length were smaller on the affected side compared to the unaffected side. Also, the skeletal age of the affected side was less than that of the unaffected side in all subjects. There was a correlation between the magnitude of differences in hand length and skeletal age with functional severity. Two other studies conducted on spastic quadriplegic children reported similar findings.[34,58] It has also been reported that the proportion of malnourished patients increased with severity of CP.[1,9,18,23,58] Growth retardation is more prominent in spastic quadriplegic and dyskinetic subtypes of CP.[4,6,10,16,29,30,59] Mild mean growth deviation has been found in ataxic subtype of CP.[9] Prevalence of underweight is also low in children with less severe forms of CP such as diplegia and hemiplegia as compared to spastic quadriplegia [Table 1] and those with GMFCS III and IV.[23–26]

V. *Age and Gender*

Cross-sectional studies evaluating children with different ages showed a greater growth retardation progressing with age among children with severe CP. In these studies,[2,5,38] age-specific measures of growth were closer to normal during infancy and toddlerhood (approximately 10th percentile). However, during middle childhood they were less than third percentile. Further, during adolescence, growth retardation appeared to be exacerbated by a less-than-adequate pubertal growth spurt. By adulthood, growth faltered below –3 SDs. A significant negative correlation was also seen between growth retardation and age in a study conducted on severely affected children.[33] In contrast to this, another study showed that those who were below 6 years of age had slightly greater growth deficiency in comparison with older children. Possible reasons behind this could be better nutritional status, higher levels of body fat, and improvements in oral motor functioning as feeding milestones were achieved.[26]

There were no researches that explicitly studied growth differences among males and females. However, still a few researchers have reported gender differences in growth among boys and girls. Spender et al.[60] found that boys had greater GH deficiency as compared to girls. Two other survey studies conducted by Sjakti et al.[26] and Stallings et al.[38]

showed that the age-specific standard scores for upper arm length were significantly greater for girls than boys. Another study had similar observations for the average reduction in height for children in their sample.[25] Two studies on the contrary had different findings where girls were found to be significantly more (p = 0.006 and 0.061, respectively) undernourished than boys.[11,23]

VI. *Socioeconomic Status and Provision of Health Care Facilities*

Relation between disability and poverty and its various components such as income and non-income greatly vary among developed and developing countries.[61] According to the United Nations population statistics,[62] approximately 70% of the total disabled people live in developing countries. Possible reasons for higher prevalence of disability among rural population include poor nutrition, limited access to vaccination programs, health and maternity care, poor hygiene, and bad sanitation.[63] Most of these can be easily prevented with proper care.[63,64]

People with disabilities may require services ranging from mild and inexpensive ones to complex and costly ones.[61] But provision of effective rehabilitation services in developing countries remains a challenge.[19,61] Researches have estimated that only 2%–3% of the rehabilitation needs are met among developing countries.[62,66–69] Although there have been various attempts to reduce marginalization of this population through community-based projects, disparities still remain in health, education, and nutritional status between children with and without disabilities.[70]

When it comes to CP, limited attention has been paid to provision of health services.[44] Identification and management of nutritional problems among these children is hampered by widespread malnutrition among the general population.[19] Among developed countries, high-technology medical procedures such as the introduction of alternative feeding methods, various other services, and expertise are available to support these children. This can be very helpful in reducing the nutritional and feeding problems among these children.[71] On the contrary, availability of such health care services is very scarce in resource-poor or developing countries.[15] Availability of low-cost, low-technology solutions required to address these problems in the developing world still remains a challenge.[27]

Certain factors in the environment such as strict adherence to feeding schedule and intensive medical treatment have also been shown to affect growth among children with CP.[72] In situations of poverty, feeding and nutritional problems among these children are increased due to lack of resources to buy nutritious food, limited time and facilities for cooking separate recipes, and lack of awareness among the caregivers.[27] Moreover, the burden of care for a child with CP falls entirely on the family due to poor availability of health services. As a result of this, 90% of the children living in developing countries are reported to have feeding difficulties,[45] leading to poor nutritional status.[41] Only a handful of studies have reported anecdotal comments about the neglect and poor nutritional status of children with disabilities. In some communities, disabled children are fed inadequately because they are considered sick and they fear of making the illness worse by feeding more.[73] A qualitative study was conducted in an Indian slum to explore families' experiences of feeding problems in a resource-poor community.[74] It was reported that provision of adequate amount of food was very difficult within all the households either due to lack of resources and time or poor appetite of the disabled child. However, families were aware of the problems their child faced and wanted information on managing feeding problems and improving eating habits of their child.

Because of all these reasons, malnutrition has been found to be higher in lower socioeconomic class.[16,18] In contrast to this, one study concluded that socioeconomic factors were not responsible for poor linear growth among children with CP.[7] Various studies have been conducted in both developed and developing countries to assess the nutritional status and growth among children with CP. Despite of using different inclusion and exclusion criteria, it can be clearly seen from Table 1 that children in developing countries have poor nutritional status as compared to those in developed countries. Prevalence of underweight (weight for age z-score below −2 SD) is 48% in Greece,[10] 29% in North America,[26] and 20% in Norway,[9] compared to 35% in Turkey[28] and 51% in Brazil.[16] Although in the North American study, children with only milder forms of CP (diplegia and hemiplegia) were included, prevalence of underweight was high[26] compared to Norway wherein all forms of CP were included.[9] Similarly, in Malaysia,[7] the prevalence of underweight (weight below fifth percentile), all types included, was 78%. This was very high compared to that reported in another study where 47% children had weight less than fifth percentile.[23] In both the cases the population belonged to urban community. In India, 86% children with CP had protein–energy malnutrition.[29] A possible reason for such a high prevalence could be that the sample was taken from a hospital where the severity of cases was high. These children may not be truly representative of all the children with CP as those attending the hospital might have severe problems or may be malnourished due to long periods of hospital stay. Two other studies conducted in North America[25] and one in Taiwan[11] reported that nearly half of the children with CP were underweight (weight below 10th percentile).

Stunting (height for age) has also been reported to be more prevalent among developing countries as compared to developed countries. In developing countries, stunting (height for age Z score ≤2 SD) was prevalent in 23% and 20% of children with CP (all types) in North America[26] and Norway,[9] respectively. In developing countries, prevalence was high being 30% and 39% in Turkey[28] and Brazil,[16] respectively. Very few researchers have looked into wasting (weight for height Z scores), skinfold measurements, and MUAC. Skinfold measurements and MUAC have been listed in Table 3. Owing to different inclusion and exclusion criteria and use of different standards, the results could not be compared between developing and developed countries.

Table 3: Skinfolds and MUAC measurements of children with CP

Study	Country	Description of sample	Growth standards used	Prevalence of low MUAC	Prevalence of low triceps skinfolds	Prevalence of low subscapular skinfolds
Caram et al.[26]	Brazil	Sample size: 114 Age: 2–12 years Type of CP: all	–	30% below –2 SD	30% below –2 SD	30% below –2 SD
Samson-Fang et al.[23]	6 Sites in North America	Sample size = 235 Age: 2–18 years Severity: moderate to Severe	NCHS	32% less than 10th percentile	27% less than 10th percentile	44% less than 10th percentile
Zainah et al.[7]	Malaysia	Sample size: 101 Age: 2–12 years Type of CP: all	Age- and gender-specific reference data derived from another study	51.5% below 5th percentile	40% below 5th percentile	–

MUAC, mid upper arm circumference; SD, standard deviation

Conclusion

Nutrition is an important area of the management in children with CP. Ill effects of malnutrition on physiology, motor, neurological, and psychological functions are wide ranging.[35] Malnutrition may cause impairment of the immune system, cognitive problems, and neuromuscular disabilities.[11,30] Children with CP who have very low weights are at increased risk of death.[75] With increase in severity of CP, the mean number of chronic medical conditions also increases.[75] Researches have shown that an improvement in nutritional status results in improvements in general health.[11]

These children face a lot of obstacles toward reaching a normal growth. Most of these children are underweight, stunted, and/or wasted. Various factors such as inadequate dietary intake, feeding problems, motor impairment, endocrine abnormalities, and socioeconomic status are responsible for this growth faltering. Moreover, it has been seen that poverty, ignorance, and lack of health care services in developing countries further worsen the situation. Dietary intake and feeding problems and provision of adequate health care facilities can be easily modified to bring about a change in their nutritional status. Therefore, it becomes the duty of primary caregivers and pediatricians to be in contact with these children and their families, to be more vigilant about the possible causes responsible for poor growth among this population. Their growth should be monitored closely from time to time so that appropriate timely actions can be taken to improve the health and quality of life of these children and their families.

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