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Original article

Progress in nutrition in cerebral palsy children - A literature review

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Summary. Cerebral palsy (CP) in children is highly prevalent. Despite this fact, however, nutritional care in CP children has not been given much of the research attention. Nutrition is usually overlooked for many reasons, but mostly because the medical physicians are usually not skilled in nutritional care. This gap needs to be filled through numerous approaches. In this explanatory review, we present a brief overview on CP children and their nutritional care; how is growth and nutritional status assessed in CP children? What are common feeding problems of CP children? What is the status of CP in developing countries like Saudi Arabia? These are important questions since the overall health of CP children depends mainly depends on how they are nutritionally cared.

Key words: nutrition, cerebral palsy, growth, nutritional status, Saud Arabia

Introduction

Cerebral palsy (CP) is a common motor disability in child age and has been reported to be the main reason for severe physical disability (1). CP is a syndrome of symptoms resulting from premarital brain damage. As a result of functional development disorders, the pathology of muscle tone and delay the occurrence of correct motor reactions and attitudes to clinical consequences of an administration with varying degrees of severity (2, 3). The disorder is associated with a number of other disorders, including growth deviations and nutritional deficiencies (4).

Growth and nutrition disorders are common in chronic neurological diseases in children (6,7). In children with chronic neurological diseases observed in growth delay, no growth or release rate of weight gain, reduction in fat and lean body mass and reduced weight bone (9). Consequences of malnutrition in the course neurological diseases are very complex. A loss of safety fat mass, mainly muscle mass, causes deterioration of motor function, weakness respiratory muscles and thus increased risk the development of infectious complications of the respiratory system. Nutritional management results in weight gain, the thickness of the skin folds, the increase of fat-free mass body and bone mineral density (10,11,12). The positive impact of nutritional intervention was also on the quality of life of patients and their families (13,14).

Growth deviations and impairment of nutritional status in CP patients is very common (1). The body composition of CP children is characterized by tremendous drop in the muscle mass as well as a decrease in essential fat mass and bone density (1, 5). The optimal nutritional status is one of the most important factors for a healthy growth and well-being in CP children (4, 6). Therefore, it is important to avoid muscles mass and fat tissues losses and also to maintain the functions of the respiratory and myocardial muscles, immune system, nervous system, movement, cognitive state of healing and tissue repair in wound and bedsores (7).

Despite the fact that nutrition has a great promise in health of CP children (8, 9), nutritional care is usually not a priority area in the medical care process of CP children. A global consensus on which growth

charts curves to be used for the assessment of CP children is non-existent (10-12). This lack of consensus is one of the factors responsible for poor growth monitoring of CP children.

Nutritional requirements of CP children are different from those of the normal children. The nutritional requirements of CP children vary according to the degree of their motor disability and level of physical activity. However, it is essential that children with CP should have a dietary intake that may cover the recommended nutrient requirements for their age- and sex-matched counterparts (12).

Saudi Arabia is one of those countries where there is relatively higher prevalence of CP children (13-15). However, only a few studies (e.g. Rf 4) have considered issues related to physical growth and nutrititional status of these cildre. Moreover, s little evidence, if any, exist about the clinical and nutritional interventions carried out in Saudi Arabia on CP children (16).

Nutritional care of CP children is of vital importance taking into consideration the complexity of the disease and the associated higher morbidity and mortality rate. Making visible the power-related problems could motivate health professionals to strengthen care networks that generate interventions to improve the life-quality of children and adolescents. Nutrition, in this connection, no doubt, has a strong role to play. In this review, we try to appraise the nutritional care of CP children with a focus of the disease in the context of Saudi Arabia.

What is Cerebral Palsy

For the first time in 1861, William Little reported CP and therefore, the disease was initially called "Little's disease" (17). Cerebral palsy is defined as a disease that "*describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorder of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behavior; by epilepsy, and by secondary musculoskeletal problems*".

Situation of CP in Saudi Arabia - incidence, prevalence and nutrition

In Saudi Arabia, several studies have reported CP, of which mostly focusing on its incidence and prevalence (13-15), some on the associated risk factors (13-15, 18-20), a fewer on relation to other diseases (20, 21), and only a very small fraction of studies on growth problems and nutritional status (13). However, various studies done on the prevalence rate of CP in Saudi Arabia are lacking agreement on the incidence and prevalence levels of CP in children in Saudi Arabia. For example, Al Salloum et al. in one of the most recent studies, identified 2.34% per 1000 live birth of CP prevalence rate and described it as the "most common neurologic disorder among Saudi children" (14). These figures on prevalence are almost the same as reported for the developed world, the UK, for example (22).

Some studies have reported the associated risk factors that are usually found in CP children in Saudi Arabia (13-15, 18, 23). The most important risk factors include CP history in sibling and parental consanguinity (15), certain natal, prenatal and postnatal factors (23), twins birth, low birth weight, and pre-term delivery (4). Studies conducted on the nutritional health and dietary intake of CP children reported growth deviations, nutritional status and nutrient intake of CP children (14). Whatever, we know from these few studies on nutrition that the CP children have a poor growth pattern, impaired nutritional status and suboptimal energy intake.

The most frequent cause of disability in children has been reported to be the neurological diseases as cerebral palsy (24). Motor alterations are frequently accompanied by sensory, cognitive, communication and perception alterations (25). The disease affects gross motor skills to variable extents; that needs to be observed in the first 12 to 18 months of life, when the child fails to achieve his/her normal motor functions and manifests qualitative differences in motor development (26).

CP is a multifactorial syndrome and, in general, offers three types of etiologic factors: (A): prenatal factors, such as maternal factors, alterations of coagulation, autoimmune diseases, hypertension, intrauterine infection, trauma, toxic substances, dysfunction

thyroid, abnormalities of the placenta; (B): perinatal factors such as prematurity, low weight, maternal fever during labor, systemic or infection of the Central nervous system, maintained hypoglycemia, hyper-bilirubinemia, intracranial hemorrhage, hypoxic-ischemic encephalopathy, trauma, cardiac surgery or extracorporeal membrane oxygenation; and finally (C): postnatal factors, as infections (meningitis, encephalitis), head injury, convulsive status, cardiac arrest, poisoning or severe dehydration (25-27).

Classification of the Cerebral Palsy

For accurate nutritional assessment and hence appropriate nutritional care, understanding an accurate and precise state of the disease is needed. CP is not a homogenous condition and as there are higher variability in the disease conditions from patient to patient, there must be systemic tools to classify the patients. Different classification systems exist that diagnose the type, stage and severity of CP (28). The CP patients can be classified (25-28):

- Level of severity of disease
- Topographical Distribution of the disease
- Motor Function
- GMFCS or 'Gross-Motor Function Classification System'

GMFCS is the most common system of classification (24) and categorizes the patients according to their gross motor function (30). All the children with at any level of the disease are at risk (31, 32), but children who are severely impaired in their motor abilities may be more susceptible and are at higher risk (33, 34). Beside its wider application and use, GMFCS is the most reliable and validated system. Table 1 summarizes the GMFCS that is extended and revised for children (6-12 years of age) (30).

Table 1: Summarized GMFCS (Children 6 - 12 years of age)

GMFCS Levels	Gross Motor Performance
I	The patient can walks easily without restrictions but has limited ability of advanced motor skills (e.g., running, jumping).
II	The patient van walks in most settings but outdoor walking (in community) is limited.
	May need physical assistance, mobility devices that assist in walking, or even wheel chair.
	Has little/minimal abilities of running/jumping.
III	Can only walks with mobility devices; in outdoors walking faces limitations
	For long distances, mobility is on wheel chair mobility
	Physical assistance in required for transfer.
IV	Self-mobility is with limitations; in most of the setting, the patient needs powered or physical assistance
	Adaptive seating is needed for pelvis and trunk controlling
	Physical assistance is needed for most of the transfers.
V	Wheel chair mobility is required in all settings.
	For controlling head and trunk positions, the patient needs assistive technology
	The patient is totally dependent on others for transfers.

Ref: Andrew and Sullivan, 2010

Growth deviations and Nutritional status and the Cerebral Palsy

Background

Nutritional status assessment is one of the most important factors for monitoring normal growth and well-being in CP children. Nutritional status of the CP children mainly depends on the severity of the disease, the natural history of the disease, care and nutritional surveillance by the multidisciplinary team in hospitals and clinics (35). Greater degree of motor disability, worse state nutritional, and longer evolution there will be greater involvement of linear growth and weight (36).

Physical examination and Nutritional History

Physical examination and nutritional/dietary history are important components of growth monitoring in CP children. Physical examination is performed to know whether the child has been growing normally or not. Nutritional history helps in whether any growth failure is due to poor nutritional factors or other associated abnormalities. Generally, nutritional/dietary history focuses on feeding difficulties of the patients. Nutritional/dietary history also helps in finding out

whether the patient needs any increased caloric intake. In most of the cases, nutritional/dietary history is also helpful in identifying the qualitative data on dietary or nutritional intake rather than quantitative data, a fact that is investigated extensively. As an example, Stallings and colleagues (1996) indicated that quantitative oral intake assessment in CP children (quadriplegic) overestimate the amount as much as 44 - 54% of the actual requirements (37). Data on types and even causes of growth abnormalities can be assessed by a complete physical examination. The skin and nail examination may reveal some preliminary information on deficiencies of micronutrient (38) and further preventive measures can be implemented.

Anthropometry

Anthropometry is a science of measurement of various bodily physical parameters including, for example, taking weight, height, skinfold thickness etc. Anthropometric measurements in CP children is challenging as for some measurements are difficult to accurately measure. For example, measuring height/stature is difficult in CP children due to difficulties in erectly standing. This is due to the presence of contractures joint, muscle weakness, scoliosis, involuntary movements and little cooperation from the child or adolescent, that make inaccurate, unreliable, and sometimes impossible to obtain the direct measurement of the size.

Stadio-meter is one of the preferred techniques for height measurement of CP children who can stand straight without support. Supine length is measured only in those patients who can lie in a position which is straight enough and the limbs align in an appropriate way. Measures of some body segments are used to estimate the size, mainly of long bones: the length of the tibia, knee height, ulnar length and segmental limb lengths. To be easy and reliable measurements, it is recommended to measure them routinely (40, 41).

In some situations, weight of the child patient can be measured by taking the combined weight of the child and the caregiver. The caregiver holds the child in the circuit of his/her lap. Weight of the caregiver is deducted from the total weight (weight of the child plus weight of the care-giver). This gives weight of the child. Certain children may want sitting, or even hoist scale or wheelchair during weighing. Nevertheless, method consistency is crucially important for getting accurate weight profile of the patients. For accurate weight measurement, guidelines shown in Table 2 have been recommended by Dietitian of Canada (42):
Measurements of weight and height should be plotted against the standards (e.g. WHO or CDC growth charts). Age and gender-specific growth charts are used for this purpose. Growth charts specifically developed for CP children are existing; however, due care be taken while using these charts as most of these are 'descriptive' and rarely proposed for normative data production (36).

Numerous techniques exist for the prediction of body fat. Body mass index (BMI) is rarely considered as the method of choice. Skinfold thickness measurements may prove a good alternative for these are cheaper and easy to do. But these are proxy body fat estimates. Triceps skinfold thickness (TST) measurement is feasible and easy. Value < 10^{th} percentile of TTS shows lower body fat indicating possibility of under-nutrition in CP children. Linear growth, pubertal development and patterns of bone age of CP children may differ with respect to those neurologically healthy. The CP children are characterized by bone density, lean mass and decreased fat mass (37). The results of the investigation of Day et al. (2007) showed that CP children have different weight and height as compared normal children of the same age and sex. In addition, CP children with mild level of disease may have almost the same growth patterns as those of normal children (37).

Specific growth charts for CP children exist, but these still need to be standardized worldwide for general use in the evaluation of the nutritional status. This is because the data are extracted from a database of a particular health system and, therefore, hardly repre-

Table 2: Nutritional Guidelines for CP children

Children who weigh less than 20 kg and are unable to stand on their own should be weighed on an infant scale.
Children who weigh greater than 20kg and are unable to stand on their own may need to be weighed held by someone, with the weight of the person holding the child subtracted from their combined weight.
A larger child unable to stand on their own or too heavy to be held, may need to be weighed on a sit-down or wheel chair scale.

sent the world's population (37). Therefore, in usual practice the growth charts developed by WHO for normal children are used for CP children (38-41).

Accurate length measures are often impossible with joint contractures, muscle spasms and inability to stand. Under these circumstances a segmental measure can be used: knee height, tibial length (also known as lower leg length) or upper arm length (Figure 1). These segmental measures can further be used for estimation of other measurements. For example, certain equations are available to convert the segmental measures to standing height (Table 3).

Body Composition

Assessment of body composition is different for anthropometric measurement. Body composition assessment separately measures components of body weight, for example, protein or lean body mass (LBM), body fat, bone content and water. Body composition is generally different in CP children as compared to age- and sex-matched normal children. For example, CP children loose most of their body cell mass, expansion in the extracellular fluid, and an increase in body fat.

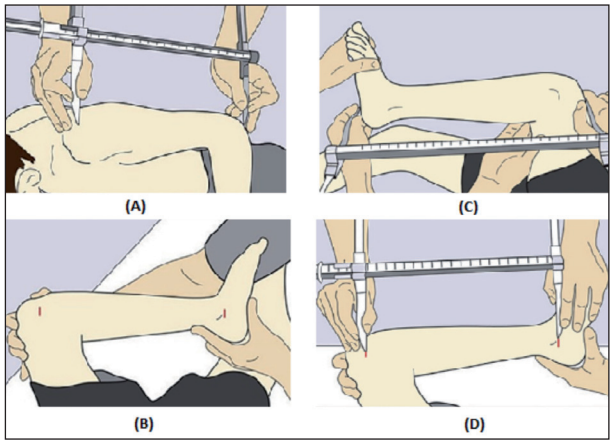

Figure 1: Segmental measurement in CP Children. (A) Measuring upper arm length, (B) Pre-marking landmarks for accurate measurement of tibial length, (C) Measuring knee height, (D) Measuring tibial length.
Adapted from: Ref 44

Table 3: Equations to estimate height from knee length

Males	Height = 40.54 + (2.22 x KH*)
Females	Height = 43.21 + (2.15 x KH*)

*KH (represented in centimetres) = knee height
Stevenson RD. Use of segmental measures to estimate stature in children with cerebral palsy. Archives of Pediatrics & Adolescent Medicine. 1995b;149(6):658-62. 63.

There are many methods for measuring body composition; some very precise but expensive and not very feasible (e.g.., doubly labeled water and DXA), some easy and more practical (e.g., bio-electric impedance: BIA, underwater weighing, skinfold thickness measurements). The DXA technique is validated for children who have different body posture (42) and may be used for CP children, if feasible. BIA can be used for body composition assessment (43), but it yet to be established whether this method is appropriate for CP children (44). Ultrasound has shown to be promising for the assessment of body composition in CP children in some of its early trials (45).

Biochemical Assessment

In some situations, the laboratory assessment is helpful in evaluating nutritional status of CP children (46). There may be some limitation; for example, serum albumin and pre-albumin were found to be not of much help in the nutritional status assessment in CP children (47). Micronutrient deficiencies are common in CP children. It is recommended that micronutrient evaluation of CP children should be done when needed (48). Biochemical evaluation is usually followed by clinical judgment and physical findings. Periodical abnormality screening is warranted, particularly for children who with severe impairment and chronic illness. Children who are at risk for vitamin D deficiency and present with signs, for example, limited exposure to sunlight, skin darkness, and use of anti-epileptic agents on chronic basis should be considered on annual visits. For monitoring of iron status anemia and screening of iron deficiencies, iron lab tests and complete blood count are advised. Identify the primary irregularities likely occurring in liver, kidney, and bone by appropriate tests of these organs (46).

Biochemical evaluation may be done once a year. In general, biochemical parameters shown in Table 4 are recommended to be performed.

Assessment of Dietary and Nutrients Requirements

Dietary and Nutrient requirements of CP children may be established before any advice on dietary and nutritional intake. Energy requirements should be

established using certain easy tools and mathematical expressions. Table 5 shows some equations that can be used for energy requirements of the CP children.

BMR: 'Basal Metabolic Rate'; BEE: 'Basal Energy Expenditure'

Nutritional intervention becomes essential in situations of poor dietary practices of CP children. In such situations, dietary supplementation may become necessary. Some dietary supplements, (e.g. glucose and long-chain triglycerides) are recommended for increasing energy intake. Alternatively, some other foods with high energy contents may also be recommended. Reassessment is recommended as a necessary step to gadget the response to nutritional intervention. Reassessment frequency depends upon how old a child is; Infants/younger children may need assessment/reassessment more frequently monthly, maybe); Older children require assessment/reassessment less frequently (may be yearly) (30).

Diet in children and adolescents with Cerebral Palsy

Common Feeding Problems

Feeding problems in CP children are common (41, 49, 49) and include a wide range of symptoms. The common feeding problems in CP children are shown in Table 6.

Constipation is a common problem CP children. The prevalence of chronic constipation in children PC is 74% and it is defined as less than 3 bowel movements per week. Intestinal motility is altered due to neurological disorders. This results in abnormally failure of relaxation of the internal anal sphincter after rectal distention, high pressure in the sphincter, and impaired rectal sensation and reduction of the propulsion colonic (41).

The factors influencing the constipation include (49):

- prolonged immobility,
- the absence of erect posture for defecation,
- bone alterations as scoliosis,
- hypotonia, dietary factors such as insufficient intake of fiber or liquids and the use of drugs as anticonvulsants.opioids, and antihistamines.

In addition to the above factors, CP children have decrease in the feeling of filling the rectum and the need for larger volumes to trigger the anorectal reflection. Emotional stress and pain are the common factors that influence bowel movement (41).

Table 4: Recommended Biochemical Assessment for CP children

Full blood count
Electrolytes (Sodium/Potassium/Chloride)/Urea/Creatinine
Total protein
Albumin
Trace elements
• Copper
• Selenium
• Zinc
Vitamins
• Vitamins A, C, D and E
• B12, Folate
Minerals
• Calcium
• Magnesium
• Phosphate
• Iron studies/ferritin.

O'Connor B, Kerr C, Shields N, Imms C. Understanding allied health practitioners' use of evidence-based assessments for children with cerebral palsy: a mixed methods study. Disability and rehabilitation. 2019, 2;41(1):53-65.

Table 5: Energy requirements determination for CP children (Andrew and Sullivan, 2010)

Method	Equation
Indirect calorimetry	**Energy intake [kcal/d)=BMR* activity* muscle tone]+growth:** where • Muscle tone=0.9 (if decreased); 1.0 (if normal); and 1.1 (if increased) • Activity=1.1 (bedridden);1.2 (wheelchair/crawling); 1.3(ambulatory). • Growth=5 kCal/g of desired weight gain (normal and catch-up growth)
Dietary reference intake standards for BEE	**Energy intake (kcal/d)=BEE×1.1, where BEE is** • Male: 66.5+(13.75*weight in kg)+(5.003*height in cm)-(6.775*age) • Female: 65.1+(9.56*weight in kg)+(1.850*height • in cm)-(4.676*age)
Height	**15 kcal/cm in children without motor dysfunction** • 14 kcal/cm (for children having motor dysfunction/ ambulatory • 11 kcal/cm (for children non-ambulatory)

Table 6: Feeding Problems of CP children

- 'inability to self-feed',
- inadequate/absent tongue lateralization,
- 'chewing problem',
- swallowing problem,
- cough/choking during feed,
- drooling,
- hypertonic tongue,
- inability to take solid food',
- constipation,
- cucking problem,
- vomiting/regurgitation',
- no closure of lips around spoon,
- inappropriate wide mouth opening
- cry/extensor dystonia during feeding

O'Connor B, Kerr C, Shields N, Imms C. Understanding allied health practitioners' use of evidence-based assessments for children with cerebral palsy: a mixed methods study. Disability and rehabilitation. 2019, 2;41(1):53-65.

Neurogenic dysphagia (ND)

ND is a disorder that causes difficulty in swallowing (oral, pharyngeal or esophageal) food (51). In CP children, it can be secondary to the innervation and motor control neurological changes that trigger changes in oral sensation and dysmotility esophageal (41). This disorder leads to eating more slowly compared with children and adolescents neurologically healthy. In addition, can cause aspiration of food and liquids in the respiratory tract, which is a major cause of morbidity and mortality in PC (41).

Gastrointestinal Reflux (GER)

The presence of GER is attributed to an alteration of the motility that affects the esophagus and the mechanism of the lower esophageal sphincter, causing retrograde and involuntary regurgitation of gastric contents into the esophagus (50). Several factors that cause GER in CP children are shown in Table 7 (41).

Table 7: Factors that cause GER in CP children

- dysfunction of neural control of esophageal peristalsis,
- modification in the innervation of the lower esophageal sphincter with subsequent episodes of transitory relaxations of the supine position prolonged, secondary scoliosis,
- increased intra-abdominal pressure,
- spasticity,
- constipation,
- convulsions,
- drugs,
- obesity
- change the consistency of the diet .

Reilly and colleagues (52) found 60% of children were totally dependent on their mother for all aspects of food; 57% had episodes of breathlessness requiring medical care at least once in their childhood; and 71% presented frequent cough and suffocation. Fear and anxiety generated by the process of feeding and the perception of the child or adolescent as more vulnerable may greatly hinder the feeding routine process. In addition, communication problems prevent or distort the application of food, the difficulty of expressing hunger or food preferences, the inability to search for it and the lack of skills of self-feeding and increased dependency (52).

Assessment of Chewing and Swallowing Problems in CP children

Modified Barium Swallow Study (MBSS) is a reliable test used for investigation of the chewing and swallowing difficulties in CP children (53). During the test, a patient's mouth, throat, and esophagus are checked. While doing the test, the patient is seated in upright or semi-upright (approximately 75°, in case of infants) position. A video is made while the patient is swallowing some food with Barium (53). The video shows how food is proceeded through various parts of the gastrointestinal tract. In this way, the technician can point out any swallowing problem or obstruction in the gastrointestinal tract.

Future Outlook

There is need of further investigations to comprehensively study the nutritional problems of CP children in Saudi Arabia. There must be specific food frequency questionnaire (FFQ) developed like those developed for children with other nutritional disorders (54). Obesity as a chronic inflammation (55) and inflammatory potential of the diet (56) are issues gaining worldwide attention and these must be studied in CP children. CP children may also need to be studied for their nutritional immunity as a special focus group like those investigations focusing specifically on elderly individuals (57-59). Finally, there is a need of both cross-sectional as well as longitudinal studies.

Conclusion

A healthy nutritional status is essential for the physical and psychological integrity of children and adolescents with PC and contributes to rehabilitation therapy to be effective. Most of the research in this population has shown that malnutrition is a frequent problem that primarily affects those who have problems with their motor functions and cannot achieve the growth expected for their age and sex compared with normal children. Food intake fails to cover most of the caloric requirements. Due to the absence of a national consensus on nutritional guidelines for this pathology, children and adolescents with PC should be particularly assessed to identify what disorders present and thus to prevent it before it develops into a much irreversible state of malnutrition affairs. The nutrition area which deals with aspects related to food and the nutritional status of children with CP is too complex but utmost necessary as the rest of the areas involved in the treatment of this pathology. Therefore, the inclusion of nutrition in interdisciplinary teams is essential to provide comprehensive care to enhance health and development of children, in particular, and their families, in general. However, the insertion of the degree in nutrition in this area is presented as a difficulty since it does not belong to health care providers covered in disability. The inclusion of the profession in the area of disabilities to be full, it should work since the University education of undergraduate and graduate to the inclusion of issues that respond to the needs of this group, since the providers of health services for development of comprehensive care programs and from the state for the design and implementation of public policies effective that improve the quality of life of persons with disabilities. Research in the area is essential to begin to build the path of nutritional care in disability.

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