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Musculoskeletal and Feeding Problems in Cerebral Palsy: A Review of Current Knowledge and Recent Advances

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Abstract

Cerebral palsy (CP) is the most common cause of physical disability in most developed countries, with a prevalence ranging from 1.5 to greater than 3 per 1000 live births. The widely accepted international definition is the widely accepted international definition is "Cerebral palsy 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 disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, and communication, behavior musculoskeletal, feeding and swallowing problems.

Keywords: *Cerebral Palsy (CP); Sensation; Perception; Cognition; Communication; Behavior Musculoskeletal; Feeding and Swallowing Problems*

Cerebral palsy (CP) is the most common cause of physical disability in most developed countries, with a prevalence ranging from 1.5 to greater than 3 per 1000 live births [1]. The widely accepted international definition is the widely accepted international definition is "Cerebral palsy 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 disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication and behaviour, by epilepsy and by secondary musculoskeletal problems [2].

This definition highlights the secondary musculoskeletal pathology (MSP), which the majority of children will develop with time. Children with CP do not have contractures, hip displacement or scoliosis at birth; these musculoskeletal problems develop over time [3]. The MSP may affect many aspects of the child's function, limiting their physical activity, participation and quality of life. Many studies have reported the progressive nature of MSP [4].

In 2002, Rosenbaum., *et al*. created gross motor curves describing motor development in children with CP [5]. There are five curves that relate to the five levels of the Gross Motor Function Classification System (GMFCS). Gross motor skills are achieved quickly in the first two years of life, before beginning to slow and then plateau between four to six old. Between six and twelve, gross motor function deteriorates at GMFCS Levels III, IV and V, which is coincident with the pubertal growth spurt and the progression of musculoskeletal deformities [6].

In 2008, Hagglund., *et al*. reported that in a population of children with CP aged between 0 to 15 years of age, muscle tone [7], as measured by the Modified Ashworth Scale, increased up to the age of four, followed by a spontaneous decrease in muscle tone each year up until age twelve. The MAS is a six-level ordinal scale from zero, (no increase in tone) to four (the body part is rigid in flexion or extension). The higher the score, the more spasticity is felt on the passive motion of the joint [8].

In 2014, Mudge., *et al*. published normative reference values for lower limb joint range of motion (ROM), bony torsion and alignment in typically developing children (TDC) aged four to sixteen [9]. The key finding of their study was that in TDC, joint ROM decreases over time, with age and onset of skeletal maturity. Nordmark., *et al*. 2009, also reported decreasing ROM in the lower limb joints of children with CP over time [10]. They reported a decreasing mean ROM between the age of two and fourteen in all joints measured. The decrease in joint ROM varied according to GMFCS level and CP subtype [11].

In 2006 The Manual Ability Classification System was developed. The MACS classifies how well children aged 4 - 18 years with CP use their hands when handling objects in daily activities. It is designed to reflect the child's typical manual performance, not the maximal capacity. MACS level is influenced by environmental and personal factors. Like the GMFCS, the MACS is a five-level system where level I represents the best manual ability and level V indicates that the child does not have any active hand function (Table 1). Good validity and reliability have been reported [12].

GMFCS	MACS
Level I Walks without restrictions, limitations in more advanced gross motor skills	Level I Handles objects easily and successfully
Level II Walks without restrictions, limitations walking outdoors and in the community	Level II Handles most objects but with somewhat reduced quality and/or speed of achievement
Level III Walks with assistive mobility devices, limitations walking outdoors and in community	Level III Handles objects with difficulty; needs help to prepare and/or modify activities
Level IV Self mobility with limitations, children are transported or use power mobility outdoors and in the community	Level IV Handles a limited selection of easily managed objects in adapted situations
Level V Self mobility is severely limited, even with use of assistive technology	Level V Does not handle objects and has very limited ability to perform even simple actions

Table 1: *Summary of the criteria for the gross motor function classification system (GMFCS) and the manual ability classification system (MACS).*

Source: Carnahan., et al. 2007 [14].

Scoliosis (Cobb angle >10_) was found at all GMFCS levels; however, the majority of curves at GMFCS levels I and II were small but curves > 40 develop almost exclusively in those who are non-ambulatory (GMFCS IV and V), have severe fine motor Impairment (MACS IV and V) and dystonia or mixed movement disorder [13].

Children with CP are particularly vulnerable to malnutrition. Reasons for this include physiological factors such as dysregulation of growth hormone secretion and muscle spasticity [15]. Feeding difficulties, including oral-motor impairments affecting chewing, food ingestion, and self-feeding, are common and often severe [16]. These difficulties may negatively impact the responsiveness of caregiver feeding practices, further reducing nutritional intake. At the same time, malnutrition may exacerbate physical and cognitive functional limitations among children with CP through reduced muscle strength, lower immunity and cerebral development, and other negative impacts on general health [17].

Children with CP are often on tube feeding, like nasogastric or gastrostomy tube feeding, for fulfillment of nutritional requirements. Because feeding problems mostly begin early and restricted growth is likely with advancing age, it is imperative to make sure optimal nutrition supply as soon as possible [18]. Swallowing problems (dysphagia) in CP may be characterized by poor tongue function having an impact on bolus transport, delayed swallow initiation with increased risk of unsafe swallowing or aspiration, reduced pharyngeal motility, and drooling due to reduced lip closure (sialorrhoea). Feeding problems present with prolonged feeding times or delayed progression of oral feeding skills and may lead to inadequate growth [19]. Both swallowing and feeding problems are associated with dehydration, malnutrition, aspiration pneumonia, and even death [20].

A review by Oskoui., *et al*. estimated the pooled overall prevalence of CP to be 2.11 per 1000 live births [21]. With the exception of those with profound intellectual deficits, most people with CP survive into adulthood. As the impact of swallowing and feeding problems can be far-reaching, particularly in paediatric populations with associated developmental challenges, early diagnosis is critical to put evidenced-based interventions in place [22].

Conversely, some adults with CP may experience gradual regressive adverse changes in their eating, drinking, and swallowing as early as 30 years of age. Their eating capabilities may deteriorate, which are often associated with increased coughing and choking, weight loss, or more frequent periods of respiratory health problems. As such, regular assessment of swallowing and feeding are also important in older persons with CP to monitor compliance with nutritional recommendations, ongoing safety, optimal well-being, and to ensure swallowing and feeding strategies continue to be appropriate for changing oropharyngeal function and skills [23].

A systematic review by Speyer., *et al*. 2019 retrieved 42 articles reporting on prevalence of drooling, swallowing, and feeding problems in persons with CP. Pooled prevalence estimates determined by meta-analyses were as high as 44.0% (95% CI 35.6 - 52.7) for drooling, 50.4% (95% CI 36.0 - 64.8) for swallowing problems, and 53.5% (95% CI 40.7 - 65.9) for feeding problems, indicating that persons with CP are at high-risk for malnutrition and dehydration, aspiration pneumonia, and, subsequently, poor quality of life. As too few studies reported on adult populations, all pooled data were based on younger populations (0 - 18y) [24].

Advances in management of cerebral palsy

Physiotherapy has provided great achievement in the field of cerebral palsy. It helps in improving the muscle structure and function and joint range of motion and reduces contractures; some techniques used to achieve this are muscle stretching, joint range of motion exercises, low resistance repetitive exercises, progressive resistance training, functional strength training, balance training, plyometrics, and selective muscle activation by techniques such as constraint-induced movement therapy. Neurodevelopmental therapy in CP children which revealed improved function in various activities of children after the application of the intervention technique. This also reduced spasticity and improved overall function in CP children; however, there was not much improvement in walking, running, and jumping [25].

Another emergent therapy called hippotherapy has improved neck control and posture control in sitting along with the upper extremity and trunk. There is an overall posture improvement due to stimulation of balance reactions which has a positive effect on balance and spasticity. 30 - 45 minutes sessions, twice weekly for 8 - 12 weeks, produce a positive effect on gross motor function in children with CP [26]. Deep brain stimulation in the case of dyskinetic CP and electrical stimulation via tens and neuromuscular electrical stimulation (NMES) in spastic CP are two techniques to improve the strength and function of muscles [27].

The robot-assisted gait training regimen is effective in improving gross motor function in children whose both sides are affected. There was a positive effect on all the measures of gross motor function after this intervention. It also improved the locomotor ability in ambulatory children [28].

Treatment of feeding problems consists of oral care, careful feeding techniques, food modifications, and stimulation of the oral musculature. Drooling occurs in CP children due to weakness of facial muscles and neck muscles. It can be managed with neck posture control, mouth closing, tongue control, behavioral therapies, intraoral appliances, and certain medications like anticholinergic drugs beneficial for this condition. Surgical management includes removal of the salivary glands and duct ligation [29].

There is a promising possibility in the field of food texture modification. Currently, there are many efforts made by various disciplines to help individuals who experience swallowing difficulties that require food texture modification. Besides families that prepare food texture modification at home, healthcare settings and the food industry were seen as a potential part of preparing food texture modification. Additionally, a new technology of three-dimensional (3D) food printing, as mentioned by Lorenz., *et al*. [28] may help the food industry by designing food mold according to real food by forming food mold layer by layer. This technology can help reduce human resources in preparing food texture modification. However, in a qualitative study among healthcare professionals (n = 15), the finding showed that 3D food printing is costly and a lengthy process in handling the equipment [30].

Conclusion

The robot-assisted gait training regimen is effective in improving gross motor function in children whose both sides are affected, it also improved the locomotor ability in ambulatory children.

There is a promising possibility in the field of food texture modification additionally, a new technology of three-dimensional (3D) food may help in improving the swallowing problems in patients with cerebral palsy.

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