Physiotherapy in the Integrated Approach to Management of Deviated Gait Patterns in Cerebral Palsy

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CLINICAL POINTS

Cerebral Palsy (CP) gives rise to a broad range of non-progressive motor disabilities characterized by distinct abnormalities in physical growth, mobility, intellectual, social and emotional development.

Various types exist, including ataxic, dyskinetic and spastic CP, depending on the extent and site of the brain injury sustained before or during birth.

Children with CP lose attributes of the normal gait, developing deviated patterns.

A comprehensive approach to rehabilitation achieves the best results, involving medical, surgical and physiotherapeutic techniques.

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Abstract

More than 2/1000 children are born with the Cerebral Palsy, a condition causing severe motor limitations. Abnormal tone and movement result in deviated gait patterns which utilise high levels of energy, leaving patients wheelchair bound from an early age. Treatment that integrates the principles of medicine, surgery and physiotherapy is essential in the management of Cerebral Palsy. Physiotherapeutic management of CP involves Neurodevelopmental Treatment, amongst others, to improve overall ambulatory function, strengthening programmes to reduce muscle weakness and active and passive stretching to reduce spasticity. These techniques should be used in conjunction with surgical management, such as serial casting and orthoses. Injections of Botulinum Toxin type A can also significantly improve gait when integrated with physiotherapeutic and surgical approaches. An adaptable, individualised approach to management is essential.

Introduction

2 to 3 per 1000 children in Europe are born with the debilitating condition Cerebral Palsy (CP) and this incidence has not changed within the last 20 years[1]. In these cases, a non-progressive disturbance occurs in the foetal or infant brain, which causes a disorder of posture and movement development. As a result, there is severe physical limitation together with disturbances in communication, perception, cognition, sensation and, in some cases, behaviour[2]. These impairments are of great importance in everyday life, because "disabled children have the same aspirations as all children; security, respect, opportunities to learn new skills, meaningful occupation and the possibility of contributing to the lives of others"[3].

Types of Cerebral Palsy

Spastic
Increased muscle tone that is not necessarily constant

Ataxic
Loss of orderly muscular contraction - movements performed with abnormal force, rhythm and accuracy

Dyskinetic
Movements are uncontrolled, involuntary and repetitive

The extent and the location of the brain injury, which vary in different cases, determine the type of Cerebral Palsy. Definitions adopted for European classification of the disease state that there are 3 main types: spastic, ataxic and dyskinetic[1]. All types are characterised by an abnormal pattern of movement and/or posture, which may be either bilateral or unilateral.

Spastic CP is characterised by an increase in muscle tone that is not necessarily constant. Additionally, some pathological reflexes such as the Babinski response (upgoing plantar reflex) may be present. In ataxic CP there is a loss of orderly muscular coordination so that movements are performed with abnormal force, rhythm, and accuracy. In dyskinetic CP movements are uncontrolled, involuntary and repetitive.

As a consequence of the damage to the brain and certain characteristics of the illness, a child with CP learns to perform motor activities in an abnormal way and grows accustomed to such deviated patterns of movement[4].

This review intends to elaborate on the abnormal gait patterns seen in CP and to outline the various dimensions of managing these deviations. It underlines the importance of the comprehensive treatment approach, which is emphasized by current research and seems to be crucial to improve the motor function and prevent further deteriorations[5].

Deviated gait patterns in cerebral palsy

There are five recognised attributes of normal gait (namely, stability in stance, adequate foot clearance during swing, appropriate swing phase prepositioning of the foot, adequete step length and energy conservation), the goal of which is to minimise energy expenditure while walking. These attributes are lost in children with CP, decreasing their gait efficiency and resulting in increased energy expenditure.

There is no stability in stance (when the foot is in contact with the ground), because upright balance reactions are often delayed or even absent. Also impaired is foot clearance (when the foot should advance, not contacting the ground) due to knee stiffness in the swing phase of gait produced by co-spasticity of hamstrings and rectus femoris[6]. The child displays inappropriate prepositioning in terminal swing, with reduced knee extension impeding the foot's preparation to touch the ground with the heel first. Knee extension is reduced due to spasticity of hamstring muscles, which exhibit both a shorter length and a slower velocity of contraction than normal muscle. Additionally, step length is often unequal and there are high energy demands due to spasticity, which inhibits fluid movements and increases effort during walking[7,8].

In their review article, Waters and Mulroy (1997) emphasize that as the CP child's age increases, the energy demands of walking increase[9]. If adequate treatment is not implemented at the earliest stage possible, the child may be confined to a wheelchair for mobility.

Wren et al (2007), in a study based on computerised motion analysis, evaluated the fourteen identified CP gait patterns in a series of 492 patients[10]. In more than 50% of cases, both knee stiffness in the swing phase and intoeing (occurring when the feet are medially deviated during walking) were demonstrated. Other typical and common abnormalities were: flexion of the knee during midstance (when one limb supports full body weight), increased hip flexion, hip adduction and equinus gait (characterised by an excessive plantarflexion at the ankle and weight bearing on metatarsal heads)[7].

The multidisciplinary approach to management

In children with CP, the possibility of developing deviating gait patterns increases with age[5,10]. Physiotherapists can help to prevent this further deterioration by restoring the deficits. For example, flexion of the knee →

during midstance, decreased strength of extensor muscles and shortening of flexor muscles can be improved. Reversal of abnormal increase in involuntary activity of flexor muscles during gait, seen in spastic CP, is also possible.
In the case of deviated gait pattern in children suffering from CP, a comprehensive rehabilitation programme is needed. Not only should it include physiotherapy, but also surgical interventions such as orthoses and serial casting[5], to improve limb positioning and restore full range of motion. The effects of spasticity can be reduced using muscle lengthening surgery[11]. Various surgical procedures such as tendon transfers (which change the direction of deforming forces) are performed to improve posture, facilitate sitting and allow ambulation[12].

However, with surgical interventions, risks such as development of pressure sores caused by prolonged bed rest or casts, nerve injuries and postoperative morbidity and mortality need to be considered. Additionally, because of the time spent in hospital a child may become socially isolated and frustrated[11,13]. Thus, if a similar effect to that of surgery can be obtained by using different treatment technique, surgery, due to its various complications, should be avoided.

Neurodevelopmental treatment to improve overall ambulation

Among many physiotherapy strategies such as Vojta therapy, sensory integration, Temple-Fay, biofeedback and hippotherapy (therapeutic horseback riding)[14], Neurodevelopmental treatment (NDT) is the most commonly used intervention to improve overall function in both children and adults with CP[15,16]. Vojta therapy, sensory integration, Temple-Fay and NDT are neurophysiological approaches designed to enhance motor development of the child[14], while biofeedback uses electronic or electromechanical instruments to generate visual or sound signal in response to the patient's muscle activity, raising their awareness and increasing voluntary control[17].
In NDT, physiotherapists help children to activate appropriate muscles and minimize the use of inappropriate ones to facilitate the completion of a task[18,19]. Completion of these motor tasks is a first step towards achieving a goal dictated by the child's functional needs, in addition to decreasing the energy required for movement. This technique also leads to the establishment of new patterns of movement[18].

Tsorlakis et al (2004) revealed a significant improvement in gross motor function of 38 children with spastic CP after participating in an intensive 16-week NDT intervention program[20]. NDT is thought not only to help patients build strength and flexibility but to improve overall functioning[21]. In an example from Tsorlakis's study, after intensive NDT treatment, the postural control of a 3-year-old female was improved, enabling her to stand for longer on her affected lower limb, walk up stairs unaided, jump and kick a ball[20].
However, studies regarding the efficacy of NDT are inconsistent. Many authors report that this technique has no significant results and identify methodological problems inherent in studies evaluating the treatment, such as infrequency of intervention or lack of validity in outcome measures[15,22].

Strengthening programmes to combat lower limb weakness

Wiley and Damiano (1998) have shown that children with CP experience lower extremity weakness[23], and this is another factor that can pose difficulties for them when performing movement tasks. Moreover, it is commonly known that there is a correlation between the degree of neurologic injury and the extent of weakness of extremities[24]. Thus, strengthening exercises should be incorporated into the treatment programme. In a systematic review of the effects of strengthening programmes for patients with CP, Dodd et al (2002) found that such programmes improve motor activity without adverse effects[25].

In a study of the effects of muscle strength training on the gait, sixteen children underwent an eight-week strength training programme using individually designed sets of exercises[26]. In this study, the children performed lower extremity exercises using body weight, rubber bands or free weights for resistance. The only muscle group that seemed to be difficult to activate was dorsiflexors of the foot, and training of this muscle group produced no effect. For other muscle groups, however, the study showed that such individually designed sets of exercises performed for eight weeks can improve muscle strength and have a positive effect on a child's gait.

However, taking the patient's impaired voluntary movement control into consideration, it can be surmised that free-weight training could in some cases be difficult to implement. Synergistic movement pattern therapy to coherently activate groups of muscles offers a common alternative treatment to weight-lifting exercises[24].

Surgery, botulinum injection and physiotherapy to reduce spasticity

The findings of Tardieu et al (1982) suggest that muscle increases its length and reduces its spasticity in response to serial casting (a process involving periodic immobilisation of a joint in a specific alignment)[27]. Further uncontrolled studies by Brouwer et al (1998) confirmed the same thesis[28]. A review of randomised clinical trials by Teplicky et al (2002) suggests that using casts, orthoses and splints to manage lower extremity abnormalities in children with CP improves the range of motion at the ankle and leads to enhanced quality of walking by increasing the step length and decreasing toe-walking[29].

Serial casting, together with injections of Botulinum toxin type A (BTX-A), have in the past 15 years become a popular combined treatment for children with spastic CP[30]. Produced by the anaerobic bacterium Clostridium botulinum, Botulinum neurotoxin is an extremely poisonous biological substance. If injected locally to muscles with great spasticity, it causes partial denervation of the muscle for up to 4 weeks by inhibiting the release of acetylcholine at the neuromuscular junction. Injection controls hypersecretion of cholinergic neurons and causes overactive muscles to relax[31]. By reducing spasticity, intramuscular injection of BTX-A improves the mobility and delays the need for surgery[32].

In a multicenter randomised trial performed on 46 children with spastic CP, Scholtes et al (2007) found that injections of multilevel Botulinum toxin A, followed by comprehensive rehabilitation, had a significant effect on knee extension during gait. In patients exhibiting flexion of the knee during midstance, it increased muscle length and decreased spasticity in injected muscles[5]. ➔

BTX-A injections provide good conditions for intensive physiotherapy involving active and passive stretching of flexor muscles, as well as extensor muscle strength training, functional mobility training, and gait pattern training. This trial showed that such a combination of medical treatment and physiotherapy is successful; it significantly improved the deviated pattern of gait in CP children.

Furthermore, the findings of a small case series suggest that the BTX-A injections can help improve other deviated gait patterns, such as equinus gait[33], one of the most common gait deformations among children with CP[34].
Although the use of BTX-A in management of paediatric gait disorders is widely accepted, injections on their own will not result in a long term effect. Only if applied in conjunction with treatments such as serial casting, orthoses and physiotherapy, providing an integrated approach to the management of CP, can this therapy produced a significant long-term improvement, with the spasticity-reducing effect of BTX-A lasting up to 1 year[35].

Conclusion

Management of the severely debilitating condition CP is complex. When addressing the deviated gait patterns characteristic of the neurological condition, physiotherapy must address lower limb weakness and spasticity, in addition to focusing on overall improvement in ambulation. Currently, the most widely used approach is Neurodevelopmental Therapy (NDT), despite conflicting evidence over its benefits.
Taking into account various types and the differing extent of brain injury seen in CP patients, Nawotny says that there is no universal management plan for those who suffer from this condition. Moreover, the multiplicity of therapeutic methods implies that, in fact, no method is ideal[4]. Many approaches, when applied alone, appear to have a short lasting or even no effect[19,33]. Thus, there is a need for integrated multidisciplinary treatment and an individualised approach to the management of each patient.

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