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PHYSICAL THERAPY APPROACHES FOR REHABILITATION OF CHILDREN WITH CEREBRAL PALSY: A REVIEW ARTICLE

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ABSTRACT

Rehabilitation of children with cerebral palsy (CP) includes several approaches and techniques, ranging from conservative and conventional techniques to more complex motor learning-based theories, such as neurodevelopmental treatment and sensory motor integration. Motor disorders seen in CP are frequently accompanied by disturbances of sensation, cognition, communication, perception, and/or behavioral disorders; thus, therapy approaches are arranged to meet the individual child's needs. Application of evidence-based methods ensures maximum gains in children. Successful physical therapy protocols are based on task-specific exercises and active participation which induce potential plasticity of the central nervous system (CNS) and thus improve motor recovery. Rehabilitation of children with CP is directed to enhance motor development, gait, balance and functional capacity. The goal of this review was to present different techniques commonly used in rehabilitation of children with CP.

Key Words: Cerebral palsy, rehabilitation, physical therapy,

INTRODUCTION

Cerebral palsy (CP), one of the most common developmental disabilities, is a bracket term given for a set of neurological disorders characterized by disorders of movement and posture causing activity limitation attributed to a static disturbance in the developing brain, often accompanied by associated impairments and secondary health conditions. CP is not a single pathological entity and encompasses disorders in various motor functions including but not limited to body movement, muscle control, muscle coordination, muscle tone, reflex, fine motor skills, gross motor skills, oral motor functioning, posture, and balance **(Das and Ganesh, 2019)**. CP is described using different classifications primarily motor type, topography, and motor severity. Numerous classifications and sub-classifications of CP have been proposed. The most common classifications include muscle tone disturbance and motor dysfunction **(Rosenbaum *et al.*, 2007)**. It is classified based on the type of muscle tone disturbance into (i) spastic (ii) dyskinetic (inclusive of choreoathetoid and dystonic) (iii) ataxic

(iv) hypotonic and (v) mixed. spastic CP is the commonest and accounts for 70%-75% of all cases, dyskinetic - 10% to 15% and ataxic is less than 5% of cases. The topographic classification of CP is monoplegia, hemiplegia, diplegia , quadriplegia; monoplegia and triplegia are relatively uncommon. There is a substantial overlap of the affected areas. In most studies, diplegia is the commonest form (30% - 40%), hemiplegia is (20% - 30%), and quadriplegia accounting for (10% - 15%) **(Oskoui *et al.*, 2017 and Johnston, 2020)**.

Children with diplgic CP have an upper limb impairment, which can influence the capacity to perform and participate in activities of daily living (ADLs). This impairment results from spasticity, impaired sensation, and reduced strength. Consequently, the functional ability or quality of the upper limb is often compromised. These children regularly have unpredictable patterns of prehension, weakness, spasticity, incomplete fractionation of fingers, and sensory disturbance **(Khamis *et al.*, 2015)**.

As identified by **Günel, (2011)** pediatric rehabilitation requires a multidisciplinary treatment (MDT) approach in order to promote the independence of the child with impairment, both functionally and psychologically and increase the quality of life of both the child and their family. Physiotherapists, viewed as the 'movement expert', play a key role within this MDT. The main aim of Physiotherapy is to support the child with CP to achieve their potential for physical independence and fitness levels within their community, by minimizing the effect of their physical impairments, and to improve the quality of life (QoL) of the child and their family who have a major role to play in the process.

Gross motor skills, functional mobility of the trunk or extremities in the management for the motor deficits, positioning, sitting, transition from sitting to standing, walking with or without assistive devices and orthoses, wheelchair use and transfers, are all areas that the physiotherapist works on using a wide range of physiotherapeutic approaches to influence functional ability of the child **(Patel, 2005)**.

Trunk and extremity motor impairments in CP lead these children to remain long periods without physical or aerobic activities, or harming their cardiopulmonary capacity, stability, muscle strength, and agility. To overcome this issue, in the rehabilitation of CP, there have been several major therapeutic practices during past years, including models of treatment that have been adopted as good practice and accepted as conventional approaches to treatment. Additional, well-controlled, randomized trials are needed to establish efficacy and to define the most appropriate roles for new technologies in physical rehabilitation interventions for children with CP **(Aisen *et al.*, 2011 and Tatla *et al.*, 2013)**.

Spasticity is the main dominating symptom impeding the whole functional mobility, flexibility and postural stability; therefore, the main

objectives of physical therapy of patients with CP are reduction of spasticity and maintenance of the range of joint movements in order to preserve physical mobility. It was customary to avoid muscle strength training in children with CP because such programs were thought to increase the severity of spasticity and reduce the range of motion **(Kim and Seo, 2015)**. Recently several studies revealed that muscle strengthening in individuals with CP has become a common therapeutic intervention to improve strength and function and while it is most often presented as stand-alone training, it can also be combined with other types of intervention such as motor learning and aerobic training **(Scholtes *et al.*, 2010)**.

Strength training in individuals with CP

Strength training was not at the forefront for children with CP because it was believed it would increase spasticity. However, this has not been supported by the previously uncontrolled studies showing that strength training can increase lower extremity muscle power without increasing spasticity in these children **(Eek *et al.*, 2008)**. Several studies have provided adequate evidence for its effect on muscle power, but these effects have probably been overestimated due to the lower methodological quality of these studies **(Taylor *et al.*, 2005)**.

Other studies also have revealed the positive effects of strength training and the relationship of muscle power with activity in children with CP. Strength training in CP patients leads to increased muscle power, flexibility, posture, and balance. It also increases the activity level during daily living and improves functional activities such as walking and running **(Scianni *et al.*, 2009)**.

Although strength training for CP was once believed to increase stiffened muscles (spasticity), new studies show it is beneficial. Exercises such as resistance training, bicycle exercise, weight training, and aquatic training are shown to improve body structure and function. It is important to understand that an individualized approach is needed for each child. Strength training can help cerebral palsy patients by improving balance, flexibility, muscle strength and Posture. Strength training exercises is the most worldwide intervention tool used to increase the power of weak antagonist muscles and of the corresponding spastic agonists and to provide the functional benefits of strengthening in children with CP **(Mintaze, 2009)**.

The type of strength training that is appropriate for every child depends on their individual needs and preferences. It should, however, involve increased intensity levels to ensure strength improvements are greater than what normal development would be (**Özal *et al.*, 2016)**.

Types of strengthening exercises:

1-Aqua-based training

It is water-based exercises that strengthen muscles. The special characteristics of water provide a desired environment for children and

adolescents with CP. For example, the weight lifting conditions are better in water with decreased body control amount, joint load, and effect of gravity. In conclusion, the aquatic physical activity protects joint integrity more than conditions outside. Studies have shown that performing motor skills in the water will probably increase confidence and needs less resistance to try difficult tasks when compared with training on land **(Fragala *et al.*, 2009)**. Activities in water can also be more fun and different for children, possibly increasing motivation and interest. Aquatic physical activity can be significantly beneficial for persons with higher gross motor function classification system (GMFCS) levels and marked movement limitations who may have more difficulty and be more restricted in performing physical activities outside water. In short, aquatic activities can be lifelong beneficial exercises and physical activities in these subjects of CP **(Kelly and Darrah, 2005)**.

However, aquatic activity programs for this population are few in number and the effects of these interventions have not been effectively evaluated in subjects with CP. **Kelly and Darrah, (2005)** , reported that aquatic exercise has many observed benefits on flexibility, respiratory function, muscle power, and gross motor function, but there are very few studies on its effects.

2-Isokinetic training

This is a type of resistance-based exercises that create muscle contraction at constant speeds. Isokinetic resistance training has been made possible with mechanical devices such as Cybex II that keep extremity movement at a predefined constant speed. The resistance from the isokinetic device is produced in proportion to the applied force. Increased speed is therefore met by increased resistance. The maximum voluntary effort is met by the maximum resistance within the range of motion. More markedly, isokinetic resistance exercises have been found to be an excellent & safe training type to increase both the strength and power in reciprocal movement templates **(Lee and Kang, 2013)**. The measurements made with the Cybex II, the device used in this study, have also been found to be very reliable. Resistance training is used by athletes with CP. The athletes are trained to compete in lifting weights at the CP games, an approved activity. However, advocates of the specified treatment approach feel that weight training could be detrimental for persons with CP. The potential harmful effects include increased resting muscle tonus, increased abnormal standing position, and decreased range of motion. Studies have shown that subjects with CP experience increased strength with systematic resistance exercises. However, there is no study on the effect of systematic resistance exercises on movement function in these subjects. Increased motor function can also be gained through repetitive attempts without any resistance. Training results in more effective muscle activity as shown in electromyography records following a series of training attempts. All the repeated training

attempts have been performed with normal subjects, and there are no studies on subjects with CP. The merging of developments seen in nerve-muscle performance after repeated exercises without any resistance in unrelated persons with the known nerve-muscle problems in CP indicates a need for experimental research in this area **(Dodd *et al.*, 2003 and Scholtes *et al.*, 2010)**.

3-Progressive resistance exercise

Progressive resistance exercise (PRE) training is a well-established strength training method where intensity is gradually increased. This stimulates more strength gain than related to typical growth and development. The main elements of PRE are as follows: Providing enough resistance so that a low number of repetitions [usually 8–12] can be completed before fatigue starts, increasing the amount of resistance progressively as the strength increases and continuing the training program for an adequate duration so that its benefits are seen **(Faigenbaum *et al.*, 2009)**. Systematic reviews have provided increasing evidence that strength training in children with CP increases muscle power without any side effects related to spasticity or ROM **(Mockford and Caulton, 2008)**. However, a recent review's authors concluded that strength training is not effective in children with CP **(Scianni *et al.*, 2009)**. It has also not been possible to make a decision on whether strength training is effective in improving functions such as the ability to walk. Based on the results of controlled studies, it can be recommended to include strengthening in a regular exercise routine to enable increased strength levels **(Fowler *et al.*, 2007a)**.

Daily activities only need a specific amount of muscle power (i.e., the lowest threshold). There may be increases in these lowest threshold levels and movements, but there may also be increased strength that does not provide an additional advantage for movement improvement (i.e., the highest threshold). Strength training will therefore not be the appropriate treatment option if the aim is to improve mobility. Other components such as balance and coordination may affect the improvement in motility more than muscle power by itself **(Shortland , 2009 and Scholtes *et al.*, 2012)**.

In conclusion, functional PRE is said to be effective in increasing muscle strength in children with CP. PRE can also be included in a more intensive treatment regime or can be used as a target treatment after waiting for temporary muscle weakness as seen before or after botulinum toxin A or surgical treatment **(Scholtes *et al.*, 2012)**.

4-Aerobic exercises

Children with CP suffer from weakness and low endurance. The size of the effect for strength changes has varied greatly between studies. This variability in results could be due to the method-related differences in intervention intensity, frequency, and duration. Bicycle riding is a rehabilitation tool commonly used in physiotherapy to improve power and

cardiovascular form and is recommended to individuals with CP as an appropriate exercise to keep in shape. Stationary bicycle programs can provide resistance exercises for lower extremity muscles. More studies are needed on stationary bicycle interventions for children with CP, but they have the potential to improve strength and cardiovascular form with minimum conditions for balance and motor control **(Fowler *et al.*, 2007b)**.

Treadmill training with partial body weight support (TTPBWS) is becoming more popular in the rehabilitation of children with CP. The literature on TTPBWS in CP mainly consists of case reports and small nonrandomized studies without a control group. Two reviews recently have concluded that TTPBWS can be safe and effective in increasing walking speed, while one review has stated that it could be useful to improve gross motor skills **(Willoughby *et al.*, 2009)**. On the other hand, **Mutlu *et al.*, (2009)** concluded that there is not enough evidence to determine whether TTPBWS leads to an improvement in children with CP, that the evidence is for results in children with CP is weak, and that randomized studies are required to evaluate issues such as efficacy and dose. These reviews have recommended more definite studies to determine the effectiveness of TTPBWS for children with CP. TTPBWS has also been reported to lead to changes in gait spatiotemporal parameters **(Provost *et al.*, 2007)**.

Treadmill training seems to be effective in the improvement of general gross motor skills. Different studies have evaluated the effects of treadmill training on gross motor skills. They have all reported important changes in the gross motor function measurement (GMFM) dimension (walking, running, jumping) after finding a major effect in the two groups skills (**Willoughby *et al.*, 2009)**.

5-Weight training

Although strength training seems to be safe for children of all ages when performed appropriately, loads should not be over the maximum before physical growth is completed for protect harmful effects on musculoskeletal tissues. Other safety issues include a more progressive accumulation of resistance, especially in weak children, that does not permit lifting weights by a child without supervision or hanging a weight from an extremity without muscular effort or external support. The child should not train on the same muscle groups on consecutive days. The protocol needs to be changed if there is excessive or continuing pain due to the strengthening program or if muscle stiffness increased **(Damiano, 2007)**.

6-Sports and recreation

It incorporates activities a CP patient already enjoys to build strength and endurance. Childhood and adolescence are important period when disabled youngsters develop self-confidence and their attitudes and behaviors to transfer to adulthood. Play, recreation, and sports participation have important effects on general development and are essential elements for childhood and adolescence

(Zick *et al.*, 2007). Sports and recreation have many physiological benefits thanks to regular participation in physical activities during childhood and adolescence, in addition to their psychosocial benefits. These include the increased muscle density and fat-free muscle tissue in adulthood, better management of body weight, low risk for high blood pressure and decreased feelings of depression and social isolation **(Burgeson *et al.*, 2001)**.

7- Electrical stimulation

Electrical stimulation also was used as a good tool for treatment of muscle weakness accompanied with CP children. The goal of the electrical stimulation is to increase muscle strength and motor function. Electrical stimulation is provided by Transcutaneous Electrical Nerve Stimulation (TENS) Unit which is portable, non-invasive and can be used in the home-setting by parents or the patient. Neuromuscular Electrical Stimulation (NMES) involves application of transcutaneous electrical current that results in muscle contraction. NMES has been postulated to increase muscle strength by increasing the cross-sectional area of the muscle and by increased recruitment of type II muscle fibers **(Claire *et al.*, 2004)**.

Functional Electrical Stimulation (FES) refers to the application of electrical stimulation during a given task or activity when a specific muscle is expected to be contracting. **Patel, (2005)** has shown that there is some evidence to support the use and effectiveness of NMES in children with CP but found that many of the studies are limited by confounding variables including concomitant use of other therapies, wide variation in methods of application, heterogeneity of subjects, difficulty in measuring functional outcomes and lack of control subjects.

Mintaze, (2009) proposes that neuromuscular and threshold electrical stimulation as a modality in CP is used for strengthening the quadriceps muscles in ambulatory diplegic children with CP, who have difficulty with specific resistive strength training. Electrical stimulation can be used in children with CP and adolescents to increase muscle power, improve functional capacity, and to teach the muscle its new function and strengthen it following orthopedic interventions.

8-Plyometric exercises

Functional exercises training related to specific functional activities combining aerobic and anaerobic capacity and strength training in ambulatory children, has been shown to significantly improve overall physical fitness, the intensity of activities, and QoL. A study suggests the application of plyometric exercises to the physical rehabilitation programs of children with unilateral CP could achieve more significant improvement in muscle strength and walking performance **(Elnaggar *et al.*, 2019)**. Plyometric exercises are a specific pattern of resistive strength training in which the muscle starts to contract eccentrically followed by rapid concentric contraction of the same muscle. It can jointly generate high-velocity dynamic movements and high-impact force on the

muscles and bones. Regarding muscle strength, it has been observed that plyometric exercises showed a significant improvement in muscle power and endurance. The issue of conducting plyometric training within the context of the optimization of muscle strength in children with CP is almost non-existent in previous studies **(Johnson *et al.*, 2011)**.

A meta-analysis by **De Villarreal *et al.*, (2010)** has reported the effectiveness of plyometric training to increase muscle strength in adult and pre-pubertal children. Also, a study by **Johnson *et al.*, (2011)** suggested that plyometric training is a safe exercise mode to improve motor performance and muscle strength in young children. In addition, **Ingle *et al.*, (2006)** demonstrated a considerable improvement of the dynamic muscle strength in response to a complex plyometric and resistance training in pre- and early pubertal children.

9-Upper extremity strengthening and Arm ergometer

Muscle strengthening in individuals with CP is a general treatment intervention to increase strength and function, and it can be presented as a separate training or combined with other intervention types such as electrical stimulation, botulinum toxin A (BoNTA), aerobic training, or motor training **(Elvrum *et al.*, 2012)**. Upper extremity muscle weakness is clinically important in children with CP as it is related to function. There is also evidence that upper extremity muscle weakness decreases the ability to perform daily living activities in children with CP **(Braendvik *et al.*, 2013)**.

Scianni *et al.*, (2009) and **Franki *et al.*, (2012)** reported that individuals with CP need consistent upper extremity training because CP can lead to muscle contractures and functional disturbance. Considering that the poor muscle strength in children with CP in one of the most important factors affecting motor function, increasing muscle strength is a fundamental treatment for motor performance. However, the number of studies on improving upper extremity functions through active physical training of the upper extremities in CP is limited. These studies have recommended strength training with intensive repetitions that develop upper extremity exercise capacity as rehabilitation treatment in children with CP **(Kim *et al.*, 2012)**.

Ergometers are a type of equipment used for upper and lower extremity training. It has been widely used in subjects with CP. The cycle ergometer, which is a stationary device that allows cyclic rotations in passive, active, and endurance modes, may be considered one such possibility, promoting an activity that is safe and fully adaptable to the disabilities of this population **(Santos *et al.*, 2015 and García *et al.*, 2016)**.

Cycling on a moving or stationary bicycle or on an ergometer is a standard part of rehabilitation programs in CP, as cycling promotes movement and therefore promotes the development of muscle strength of lower leg mobility, especially important for patients that are confined to a wheelchair, and as a therapy to prevent joint contractures and to increase

muscle strength. The importance of cycling for training motor function in CP has led to the development for example of adapted bicycles for dynamic cycling, and of therapeutic programs involving Functional Electrical Stimulation **(Pickering *et al.*, 2013 and Peri *et al.*, 2013)**.

Previous studies on children with CP focused on the effect of ergometer on the upper and lower extremity functions. Though arm ergometer is one of the means of upper limb movement, limited studies has been done on the effect of arm ergometer on the trunk conventional of children with CP yet **(Ojha *et al.*, 2017)**.

Studies have shown that the cycle ergometer exercise improves several parameters, such as muscle strength and endurance, along with torso control in sitting position. However, these results are presented only in a small sample. Studies with the use of cycle ergometer in the population with CP are still few and present a little information about its physiological effects **(Sandberg *et al.*, 2016)**.

However, a recent study has shown that physical therapy, such as long-term treadmill exercise, can lead to improvement in foot stiffness. It is therefore conceivable that a long-term proper exercise load can result in improvement of spasticity and expansion of the range of joint motion. While treadmill exercises are difficult to perform as exercise therapy for patients with CP and spastic diplegia, ergometer exercises are easy to perform and quantify the amount of load, making them suitable for upper and lower extremity exercise programs. In addition, long-term ergometer exercise in people with CP has been reported to improve motor function **(Williams and Pountney, 2007)**.

CONCLUSION

Muscle weakness is a common disorder in children with CP. muscle strength may influence motor performance which affects ADL and develop functional activities. Strength interventions include different ways such as isokinetic training, progressive resistance exercise, aerobic exercises, weight training, upper extremity strengthening, aquatic training, sports and recreation and electrotherapy. Strength training in CP by has beneficial effects on body structure and function, activity limitation, and participation problems in children with CP.

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وسائل العلاج الطبيعى فى إعادة تأهيل الأطفال المصابين بالشلل الدماغى: مقالة مرجعية

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تتضمن إعادة تأهيل الأطفال المصابين بالشلل الدماغي العديد من الأساليب والتقنيات ، بدءًا من الأساليب المحافظة والتقليدية إلى النظريات الأكثر تعقيدا القائمة على التعلم الحركى، مثل العلاج القائم على النمو والتطور العصبى والتكامل الحركي الحسي. غالبًا ما تكون الاضطرابات الحركية التي تظهر في الشلل الدماغي مصحوبة باضطرابات في الإحساس والإدراك والتواصل و الاضطرابات السلوكية. وبالتالي ، يتم ترتيب مناهج العلاج لتلبية إحتياجات الطفل الفردية. يضمن تطبيق الأساليب القائمة على الأدلة أقصى قدر من المكاسب لدى الأطفال. تستند بروتوكولات العلاج الطبيعي الناجحة إلى تمارين خاصة بالمهام والمشاركة النشطة التي تحفز تغييرات للجهاز العصبي المركزي وبالتالي تحسين التعافي الحركي. يتم توجيه إعادة تأهيل الأطفال المصابين بالشلل الدماغي لتعزيز النمو الحركي ، والمشية ، والتوازن ، والقدرة الوظيفية. كان الهدف من هذه المراجعة تقديم تقنيات مختلفة تستخدم بشكل شائع في إعادة تأهيل الأطفال المصابين بالشلل الدماغي.