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TRUNK CONTROL AND ITS RELATION TO RESPIRATORY MANAGEMENT IN CHILDREN WITH CEREBRAL PALSY: REVIEW ARTICLE

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ABSTRACT

Cerebral palsy is a non-progressive brain lesion that causes many disabilities in children. Spastic diplegia is a subtype of spastic cerebral palsy in which the legs are the most affected limbs. They experience significant sitting, standing, and walking problems because of spasticity, excessive muscle weakness, kinematic joint abnormalities, and reduced postural control. It affects primarily motor dysfunction and causes secondary musculoskeletal problems and respiratory dysfunction from weakness of respiratory muscles, which have a common function in respiration and trunk control that by strengthening them may affect positively on both respiration and trunk control. Children with CP have insufficient ability to control postures compared to normal children because of abnormal muscle coordination patterns in the sitting position. Leads to the loss of trunk balance and resultant increases in the muscle tone of the upper and lower limbs. Respiratory muscles play a dual role in breathing and trunk balance during exercise. CP patients have impaired respiratory function because of muscular weakness and postural trunk dysfunction. One of rehabilitations tools is the incentive spirometer exercise that has beneficial for children with cerebral palsy as it is inexpensive, simple and safe for children to use. Application of incentive spirometer as a training device for respiratory muscle help in improving strength of those muscles playing a great role improving both respiration and trunk control as a part of position stability as diaphragm and abdominal muscles have role in function of both respiration and stability.

Key Words: Cerebral Palsy, Diplegia, Respiratory Muscle, Trunk Control

INTRODUCTION

Cerebral palsy (CP) is a neurological disorder caused by a non-progressive brain lesion or malformation in the child's developing brain. Primarily, it affects motor function and often comes with disturbances of

sensation, perception, cognition, communication, behavior, and secondary musculoskeletal problems. Traditionally, researchers have classified individuals with cerebral palsy based on motor type and topographical distribution, **(Wang *et al.*, 2022)**.

Children with CP have defects in postural mechanisms, including righting and equilibrium reactions, antigravity mechanism, proximal stability, and postural fixation. The ability to maintain position and movement of the body core defines core stability. Stability training involves the abdomen muscles and pelvic and shoulder muscles, which maintain postural alignment and allow movements of extremities, **(Ali, 2019)**.

Spastic diplegic is one of the commonest forms of cerebral palsy, where trunk control plays a crucial role in determining functional and gait capabilities. There are moderate correlations between trunk control and balance. Trunk control in spastic diplegic associate with active lower limb movements. The primary impairment in the trunk and impairments in lower limbs cause deviations during gait to be observed. Primary impairments in the trunk produce compensatory movements in the lower extremities by allowing the pelvis to rotate anteriorly and leading to increased hip flexion, **(Saether *et al.*, 2013)** .

In spastic diplegia, the upper extremities are less involved than the lower extremities, and the trunk is often involved. This trunk instability contributes to difficulties in postural muscle activation in task-specific conditions. Trunk control abnormalities are the major limitation to motor development in children with spastic diplegia. Trunk instability in spastic diplegic observed by oscillations in the center of pressure, altering the balance and further delaying gross motor function. The delay in gross motor function and altered balance that leads to difficulty in performing activities of daily living and poor walking abilities, **(Dasoju *et al.*, 2021)**.

Respiratory problems in cerebral palsy:

Cerebral palsy causes physical dysfunction, such as motor and respiratory dysfunction. Motor disturbance of CP individuals induces paralysis or weakness of respiratory muscles that leads to chest wall deformation and decreased mobility as well, restriction of physical activity, delayed development of the cardiopulmonary system and limitations in functional capacity, **(Lampe *et al.*, 2014)** .

Respiratory dysfunction is a common problem because of the motor impairment of the respiratory muscles in children with CP. These

children may cope with poor coordination patterns, low tidal volume, and decreased cardiopulmonary capacity in respiratory muscles. As a result, parenchymal lung pathologies are present. As a result, these pathologies can also affect motor development and performance of ADL in children with CP, **(Kurz *et al.*, 2014)** .

The reduced strength of the respiratory muscle might contribute to the low pulmonary functions in CP children. Decreased chest wall mobility because of insufficient respiratory muscle strength (mainly diaphragm and intercostals), lead to ineffective alveolar ventilation, poor airway clearance, shortness of breath and increase risk of developing atelectasis, pneumonia or chronic respiratory failure, **(Boel *et al.*, 2019)** .

Cerebral palsy and trunk control:

Cerebral palsy causes insufficient trunk stability because of failure to achieve co-activation of proximal muscles arising from lack of experience and delayed development. This causes difficulties in the voluntary movements of all limbs and, in particular, weakening of the abdominal muscles induces not only functional difficulties in normal development but also problems in respiratory functions. Researchers assert that children with cerebral palsy can improve respiratory functions by executing trunk muscle strengthening exercises. These exercises not only enhance trunk stability, upper arm functions, and balancing ability, but also affect pulmonary function, **(Vera-Garcia *et al.*, 2007)**.

The musculoskeletal system maintains balance and achieves trunk stability by co-activating the diaphragm, intercostal muscles, medial/lateral internal oblique muscle, and rectus abdominis. These muscles have function in breathing, controlling inhalation and exhalation, in the event of interference in movement or during minor exercise. Stated that stability needs to be achieved through harmonious activation and cooperative contraction of muscles at the front, rear and lateral aspects of the trunk for the spontaneous changes in posture, diversified movement speed and changes imparted on the spine in order to improve trunk stability, **(Kwon and Kim 2018)**.

Trunk control and respiratory muscles:

Trunk control is one of the primary aspects providing postural control and children with diplegic cerebral palsy frequently show impaired trunk control, which can affect performances of activities of daily life such as sitting, reaching and walking. Children with CP have a limitation with activities because of the existing impairments in independent walking, climbing stairs, running, or walking over uneven

surface. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception; cognition, communication, and behavior, by and by secondary musculoskeletal problems like postural abnormalities affect trunk control, **(Ali, 2019)**.

Trunk control includes selective trunk movements, and trunk stabilization for active and selective movements of different parts of the body, such as limbs and especially important for equilibrium during walking. Trunk control plays an important role in achieving efficient locomotion with the interaction of the lower limb movements and upper limb and has an important role in functionality. According to the International Classification of Functioning, Disability and Health (ICF) trunk control is a bodily function, and impairment in trunk control may influence activity and participation limitations affected by mobility. Poor trunk control affects stability of the head in space thus affecting visual skills, eye-hand coordination, upper limb functions, and may cause restrictions on major life areas such as educational settings and social interaction of children with CP, **(Ozal *et al.*, 2019)**.

Trunk control is the initial frame of reference for postural control; it involves stabilization through selective movements of the trunk. Although trunk control strategies vary depending on the task and the environment, all functional tasks require adequate trunk control. When the trunk is not stable, it impairs selective movements of the extremities and head. The core area looks like a box with the anterior section of the AMs, and the posterior section includes the spinal muscles and gluteal muscles. The diaphragm and pelvic girdle muscles form their roof and the floor, so poor movement strategy and balance impairment occur in CP children because of impaired postural and equilibrium reactions and weakness in diplegic children .Trunk control ensures the acquisition of basic gross motor skills in order to develop the goal-directed activities that are essential for independent life at home and in the community Poor trunk control is the primary impairment in children, adolescents, and adults with CP, **(Saxena *et al.*, 2014)** .

Researchers linked the observed impairment in pulmonary function to reduced exercise tolerance because of limited physical activity and immobility of the chest wall, which resulted from reduced neuro-muscular control and musculoskeletal impairments in CP. poor postural control, spasticity, impaired activation, and weakness of the muscles of respiration predispose children with CP to impairment of respiratory function, **(Boel *et al.*, 2019)**.

In the spastic type of cerebral palsy with high muscle tone, the lack of spine mobility and stiff ribs causes the rib cage to not expand in front/rear, left/right, up/down directions, resulting in immature diaphragm respiration upon expiration. This leads to a reduction in forced vital capacity and forced expiratory volume at one second. Also, since the maximal inspiratory pressure is difficult to maintain because of the delay in diaphragm contraction, the children with cerebral palsy of spastic type had attempted shallow and rapid breathing. The repetition of such irregular respiration periods disables inspiration for a long time, leading to a reduction in abilities to maintain peak expiratory flow and maximal expiratory pressure, **(Marpole *et al.*, 2020)**.

Children with spastic cerebral palsy have weak anti-gravitational potential in an upright position, which, with the ribs' insufficient concave position, the chest mechanics in the sagittal and lateral planes reduces. Insufficient tonus of the internal intercostal muscles, oblique abdominal muscles and the diaphragm fibres (sternal part) lower the sternum with inspiration. This together with insufficient chest decompression flattens the breathing, increases the breathing rate, reduces the ventilatory capacity, and leads to abnormal chest wall development, **(Ozal *et al.*, 2019)**.

The ability to expand the thoracic rib cage front and back, and left and right, improves the actions of external intercostal muscles and internal/external oblique muscle can further promote the increase in lung capacity by enabling better contraction of the diaphragm .In addition, researchers believe that the strength of abdominal muscles necessary for stabilizing the thoracic rib cage improves when executing task-specific movement patterns, which increase the mechanical advantages of front-back and left-right expansion of the thoracic rib cage during inhalation, **(Ozal *et al.*, 2019)** .

Diaphragm and abdominal muscles are essential for inspiration, and their weakness causes respiratory morbidity and recurrent lower respiratory tract infections in patients with neurological diseases, especially in children with CP. Weakness of the abdominal muscles influences the stability of the central tendon of the diaphragm, which may restrict lateral chest wall expansion, **(Wang *et al.*, 2017)** .

Evaluation of trunk control:

Because of the importance of trunk control, trunk impairment needs to be evaluated objectively. In the literature, there are many clinical outcome measures, such as Seated Postural Control Measure(SPCM),

Segmental Assessment of Trunk Control (SATCo), Trunk Control Measurement Scale (TCMS), Trunk Impairment Scale (TIS) and Spinal Alignment and Range of Motion Measure (SAROMM). SPCM has poor reliability; SAROMM provides information only on postural characteristics of the trunk, not on the trunk control in static and dynamic trunk control. SATCO also evaluates static trunk only; it does not contain the items for evaluating dynamic trunk control. TCMS and TIS measure both static and dynamic trunk control. TCMS is more time-consuming, while TIS is less time-consuming. In TCMS on selective movement control, children can perform some components rotation of upper trunk and rotation of lower trunk unilaterally. In TIS, children can perform the coordination components as the rotation of the upper trunk and rotation of the lower trunk bilaterally. As in children with SDCP, trunk dissociation is important to evaluate bilaterally; TIS is superior to TCMS in assessing trunk impairment in these children. TCMS consumes more time and is difficult to administer than TIS. Recent studies have shown a positive correlation between TIS dynamic sitting balance items and trunk control during gait in children with cerebral palsy. Since TIS is well-established and highly associated with the improvement needs of Physical Therapists, **(Dasoju *et al.*, 2021)** .

By regulating the center of gravity in the base of support, postural control is guaranteeing proper body placement in space, as well as maintaining body alignment and stability. In children with CP, dysfunctional postural control is a major issue. One of the key components for postural control is trunk control. The trunk, which is the core of the body, acts as a secure foundation of support during upper- and lower-limb activities, regulates balance reactions, and ensures the proper performance of functional tasks. It also plays a significant role in actions like reaching and walking, **(Apaydin *et al.*, 2018)**.

Treatment of trunk control:

Functional Electrical Stimulation (FES) applying Functional Electrical Stimulation (FES) to abdominal and lumbar muscles together,with a pattern of 10 secs ‘ON’ followed by 10 secs ‘OFF’. Intensity of 20 to 30 mA; pulse width of 2501 μs and frequency of 25-35 Hz along with the conventional physical therapy (including stretching, gait training, NDT), aiming to improve the strength of muscles and the static posture. Gross Motor Task Training (GMTT).These exercises are the collection of general functional motor exercises such as walking and standing activities, reaching sit to stand, and step-ups. Sit to stand and

step up exercises helps in improving standing balance and dynamic postural stability during gait in children with CP. Hippotherapy is provision of motor input and sensory through movement of artificial horse, and programs designed by professionals. Help in sitting and standing balance improvement. Neuro Developmental Therapy (NDT) depends on Bobath technique was used along with the conventional therapy. NDT was found to be effective in improving postural balance including standing balance and activity in diplegic whereas it fails to improve dynamic balance, speed in spastic diplegic and quadriplegic. Progressive Resistance Exercises (PRE) includes lifting weights, resisted motion. Reactive balance training It includes repetition of balance recovery, when standing on a mobile surface that can move in any direction. Showed improvement in stability (static balance), standing balance and reduce risk of fall in spastic diplegic cerebral palsy. Treadmill training Walking or running on treadmill with varying speed, with no body weight supported, partial body weight supported and full body weight supported. It shows an improvement in standing balance and overall balance in spastic CP. Trunk-Targeted Training (TTT) Trunk-targeted training mostly focused on the improvement of trunk muscle strength, improvement in postural alignment which increase thickness of abdominal muscles. Virtual Reality It includes the balance training with the use of video games to create a virtual environment by using artificial sensory information to stimulate real life experiences or activities. It helps in improvement of standing balance .Visual biofeedback includes standing on a balance board and keeping the center of pressure, represented as a red dot on a computer screen, which helps in improvement in standing and dynamic balances, **(Khan and Khan 2017)**.

Evaluation of respiratory muscles:

The evaluation of respiratory muscle strength should be an integral part of a holistic assessment and intervention of body function for children with CP. Measurements of respiratory muscle function are get from measuring pressures achieved by volitional muscles activation or electrical stimulation of the phrenic nerve or motor roots. Respiratory muscle force is indirectly measured through the pressure generated during active inspiration or expiration, **(Hull *et al.*, 2012)**.

Treatment of respiratory problems:

One of interventions for respiratory dysfunction in diplegic cerebral palsy are airway clearance techniques, positioning and respiratory

exercises. The respiratory exercises changed between studies, the duration of programs ranged from four to eight weeks and were considered to be called "breathing exercise program", feedback respiratory training, incentive spirometer exercise, inspiratory muscle training (IMT) with a threshold device as a combination of respiratory exercises and incentive spirometer exercise, **(Marpole *et al.*, 2020)**.

Previous studies have reported the significant effect of core stabilization exercises on various respiratory parameters, muscle strength, and physical fitness in different populations other than children **(Cavaggioni *et al.*, 2015 and Mustafaoglu *et al.*, 2019).**

CONCLUSION

Spastic diplegic cp children have many impairments as neural muskloskaletal and respiratory impairments There are many intervention methods for them to respiratory dysfunction and trunk control , one of a common respiratory training modalities is inspiratory muscle training which includes respiratory muscles exercises and incentive spirometer device . Wider use of the incentive spirometer exercise may be beneficial for children with cerebral palsy as it is inexpensive, simple and safe for children to use. Using of incentive spirometer as a training device for respiratory muscle helps in improving the strength of inspiratory muscles as diphragme and abdominal muscles which plays a significant role in both respiration and trunk control as a part of position stability.

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ضبط جذع الجسم وعلاقته بإدارة التنفس في الأطفال المصابين بالشلل الدماغي: بحث مراجعي

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الشلل الدماغي هو إصابة غير تقدمية في الدماغ تسبب العديد من الإعاقات لدى الأطفال. يشكل الشلل النصفى التشنجي نوعًا فرعيًا من الشلل الدماغي التشنجي حيث تكون الساقان هما الأطراف الأكثر تأثرًا. يعاني الأطفال من مشاكل كبيرة في الجلوس والوقوف والمشي نتيجة للتشنج وضعف العضلات المفرط ووجود تشوهات حركية في المفاصل ونقص في التحكم الوضعي. يؤثر ذلك بشكل أساسي على وظيفة الحركة ويسبب مشاكل ثانوية في الجهاز العضلي الهيكلي ووظائف تنفسية نتيجة لضعف العضلات التنفسية التي تؤدي وظيفة مشتركة في التنفس والتحكم في الجذع، حيث قد تؤدي تقويتها إلى تحسين كل من التنفس والتحكم في الجذع. يمتلك الأطفال المصابون بالشلل الدماغي قدرة غير كافية للتحكم في الأوضاع مقارنة بالأطفال الطبيعيين بسبب أنماط التنسيق العضلي غير الطبيعية في وضع الجلوس، مما يؤدي إلى فقدان توازن الجذع وزيادة توتر العضلات في الأطراف العليا والسفلى. تلعب العضلات

التنفسية دورًا مزدوجًا في التنفس وتوازن الجذع أثناء ممارسة التمارين. يعاني مرضى الشلل الدماغي من ضعف في وظائف التنفس نتيجة لضعف العضلات واضطرابات توازن الجذع. من أدوات إعادة التأهيل هو تمرين مقياس التنفس التحفيزي الذي يعود بالفائدة على الأطفال المصابين بالشلل الدماغي نظرًا لكونه رخيصًا وسهلاً وآمنًا للاستخدام من قبل الأطفال. إن تطبيق مقياس التنفس التحفيزي كجهاز تدريبي للعضلات التنفسية يساعد في تحسين قوة تلك العضلات التي تلعب دورًا كبيرًا في تعزيز كل من التنفس والتحكم في الجذع كجزء من استقرار الوضع، حيث تلعب عضلات الحجاب الحاجز والبطن دورًا في وظيفة كل من التنفس والتوازن.