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Review Article

PHYSICAL THERAPY APPROACHES TO IMPROVE GAIT IN CEREBRAL PALSY- A REVIEW

Elanchezhian C* and SwarnaKumari P

Department of Rehabilitation Science, Holy Cross College (Autonomous), Tiruchirapalli-620002

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ABSTRACT

Cerebral palsy (CP) is the most common lifelong disability affecting motor development. Abnormal gait is a common problem in children with CP. These children are at great risk of deterioration in their walking ability as they mature. It is essential to monitor the patient and perform gait analysis before and after an intervention. Children with CP exhibit impaired gait due to diminished cortex excitability, excessive muscle weakness, abnormal joint kinematics, and diminished postural reactions. Recent advances in basic and clinical neuroscience give hope that the implementation of effective functional therapies based on enhanced activity will be crucial in improving the level of functioning in children with CP. Many treatment modalities have been developed in the past decade, depending on the age of the child and the nature and severity of their limited walking ability. Combination with gait and balance training had repercussions in the form of improvements in gait velocity, stride length, step length variability, and balance. The provision and integration of physical therapy, medical and orthopaedic surgery management focused primarily on the lower extremities.

INTRODUCTION

Cerebral palsy (CP) is an umbrella term for a group of motor impairment syndromes secondary to brain lesions in early stages of its development. CP is the most common cause of childhood disability and is seen in 2–2.5 out of 1,000 births. Although the brain injury is non-progressive, the neuro-musculoskeletal and movement-related functions may deteriorate and cause activity limitation. The most common form is spastic diplegia. In this form both legs are more involved than the arms so that walking ability is affected. Andersson & Mattsson investigated walking ability in adults with CP and found that 79% of those with spastic diplegia were able to walk with or without walking aids, but in 51% this ability had gradually decreased and 9% had stopped walking. Children with CP show limited postural control due to injury to the central nervous system in the developing brain. In fact, poor balance control is known to be a major constraint in functional activities of daily living such as standing or walking, in which good functional balance is required in both static and dynamic positions. Balance dysfunction is one of the main factors leading to impaired mobility and postural control, influences walking after discharge and in the community-dwelling elderly, and also impacts balance control in daily life.Most children with CP exhibit an altered gait such as stiff knee gait, crouch gait, excessive hip flexion, in toeing or equinus.

A local team, which usually consists of a pediatrician, a pediatric orthopedic surgeon and a physiotherapist, is responsible for the follow up and individually tailored interdisciplinary intervention for each child with CP.

The interdisciplinary interventions addressing impairments that affect the patients' gait can be described in four categories: orthopaedic surgery, spasticity management, physical therapy and orthotics.

Physical Therapy Intervention to Improve Gait

Functional Electrical Stimulation

Functional Electrical Stimulation (FES) has the potential to meet the motor learning needs to expand movement repertoires because it can be implemented frequently during functional tasks such as walking. Muscles are artificially stimulated using an electrical current that is transmitted through electrodes placed over the surface of the skin above the target muscle and nerve. When FES is applied to the ankle dorsi-flexors during gait it can act as an orthosis by initiating a muscle contraction to dorsi-flex the ankle joint, thus allowing for improved toe clearance during the swing phase of gait.

Large amplitude movement intervention

Children are given a 20-30 minutes training session in large amplitude movement exercises, in which children were given the instruction to move ''as big as you can''. Exercises

Corresponding author:* **Elanchezhian C
Department of Rehabilitation Science, Holy Cross College (Autonomous), Tiruchirapalli-620002

included reaching, turning, sit-to-stand, walking and turning, while walking. The children were instructed and encouraged to exaggerate all prescribed movements. The children were also given the opportunity to choose one functional activity that they wanted to practice making bigger to ensure that the movement exercises were meaningful and motivating. Child initiated tasks included: jumping, skipping, kicking and throwing. Movements were performed in a blocked sequence with extrinsic encouragement provided by physical therapists. During the treatment, children were frequently asked to self-monitor whether or not they were making their movements as large as possible. After a brief rest period, the gait evaluations described above were repeated. The intervention and all evaluations were performed in one visit, lasting up to two hours including rest breaks. During gait assessments and interventions, the participants wore their own shoes. The children who required AFOs for stability kept the devices on during the gait evaluations and intervention.

Treadmill Gait Training

Children with cerebral palsy underwent gait training. Training sessions were scheduled for 30 min every day for four consecutive weeks at home. The children were allowed to split up the 30 min of gait training into periods of shorter duration as long as 30 min of total gait training time was achieved by the end of the day. Speed and incline settings of the treadmill for the initial home training was based on the settings selected at first testing session. As the child's exercise tolerance improved and the child became more comfortable with the incline and speed of the treadmill the settings could be increased. Parents and children were instructed to increase primarily the incline rather than the speed of the treadmill. The children were also asked to make every effort to place the heel of the foot on the treadmill surface in the early stance phase. The parents were instructed to encourage the child as much as possible both to maintain and achieve progression of the training and to constantly encourage the placement of the heel during the early stance phase. As discussed, the training was focused on treadmill walking with an incline and on facilitating the activation of dorsiflexor muscles (especially tibialis anterior) using a swift but controlled pace without the need to run. All children and their parents were issued with a diary in order to record the following: (i) the length of time the child had trained each day; (ii) the speed of the treadmill; (iii) the incline of the treadmill; and (iv) what, if any, additional movement activities the child had participated in that day e.g. sport. The parents were asked to report in the diary if illness or if other factors had prevented the child from training on that day. The children were asked to report to their parents how they had felt during the training (i.e. hard work, tired, happy or sweaty) and this was also documented by the parents in the diary.

Body Weight Suspension training

Dynamic suspension group received, in addition to the traditional physical therapy program, a 30-minute gait training session using the dynamic spider cage. The dynamic spider cage is a unique rehabilitation device in the form of walker with 2 meter height, 0.8 meter width and 0.8 meter depth that is mainly used to improve children's functional activities, vestibular and balance training in addition to improve strength. The therapist connected one end of the cords to certain points; that were specific to every child, and to the center of the cage. Through using cords, the therapist enabled every child to assume good posture and balance as well as to initiate voluntary movements with satisfactory precision and control. The therapist provided 30% support of the total body weight for every child through adjusting the spring scale and the elastic cords while having every child assuming the maximum voluntary postural correction. Every child was then encouraged to walk forward while holding on by hands on the cage and then while freeing hands. Also, children were encouraged to walk forward and backward with stepping over obstacles, in addition to walking sideways to the right and to the left. Every walking activity was practiced for 5-minute to sum for a 30-minute session. Every child was allowed to take 5-minute rest after the first 15-minute. The walking track is 10-meter length. Training was provided for three consecutive months.

Plantar Pressure

Foot plantar pressure was often used to observe abnormal lower limb alignment and to determine body weight across the lower limbs .When the lower limbs exhibit abnormalities in movement, numerous studies have reported the changes in plantar pressure, surface contact area, and bodyweight distribution under dynamic and static conditions. Plantar pressure reliably indicated problems of lower limb alignment and can be used as a tool to assess toe in gait in a child with cerebral palsy. Some studies indicated that outcomes of using lower extremities orthoses could present the changes of spatiotemporal gait analysis and represent the improvement of gait function. The current report is a preliminary study exploring the changes in plantar pressure and spatiotemporal gait parameters (gait speed, cadence, and stride length) while using the proposed customized external strap orthosis. The immediate changes in kinetics of the customized external strap orthosis were still unclear. Therefore, the recent studies focus on the differences in plantar pressure and gait parameters and compared the changes in foot function and path of pressure trajectory of plantar pressure, while children with mild cerebral palsy wore the customized external strap orthosis.

Repetitive passive Knee movement

The Cerebral palsy children were seated in a comfortable position, with their back fully supported by the backrest and their legs hanging freely over the side of the metal frame. The seat depth and leg plate were adjusted to fit the subject's lower extremities. For the application of EMG electrodes, the skin overlying the target muscles was prepared with an alcohol swab. The bipolar active electrodes were applied onto 6 muscles, including the rectus femoris (RF), the vastus medialis oblique (VMO), the biceps femoris (BF), the semi-tendinosus (ST), the tibialis anterior (TA), and the gastrocnemius (GA). A 2-min resting EMG data was collected as baseline.

Following measurement and preparation, each subject received CPM intervention for 20 min. The machine can move the knee in the range from -10º to 120º; however, the actual movement range for each subject was set at 80% of their available knee joint ROM. This range was chosen in order to not evoke a stretch reflex and to increase relaxation. Two angular velocities of movement, 15 and 0º/s, were executed in a counterbalanced order on two separate days. During the 0º/s control condition, the subject sat on the machine with their lower legs fastened to the leg plate with the knee in approximately 20º-30º flexion for

20 min. Subjects watched a self-selected cartoon and were asked to remain seated between times 2 and 3.

The following measurements were performed immediately before the intervention (time 1), immediately after the intervention (time 2), and30 min after the intervention (time 3), in the following order: AROM and PROM measurement for knee and ankle joints, Pendulum test, MAS, two trials of TUG, and 6MWT. ROM of the ankle was measured, since the gastrocnemius muscle was moved during the intervention and any changes in this 2-joint muscle might lead to variation in knee and/or ankle ROM. The Pendulum test evaluated muscle tone by using gravity to provoke stretch reflexes of the knee extensors during passive swinging of the lower limb. The oscillatory movements of the lower leg were captured by an electro-goniometer at the knee joint. The relaxation index was calculated as follows: RI = A1/A0 × 1.6 = (starting angle – first angle)/(starting angle – resting angle) × 1.6. The test-retest reliability of the relaxation index before the intervention was 0.76. A MA with a score of 0-4 was used to assess the resistance of knee flexors to passive movement. The MAS scores of bilateral extremities were added up to represent the muscle tone of the subject's lower extremities. The TUG and the 6MWT were performed by having the subjects walk with shoes on at their preferred speed with or without assistive devices. The TUG measured the time required for an individual to stand up from a chair with armrests, walk 3 m, turn, walk back to the chair, and sit down. The mean performance time for two trials was calculated. The6MWT is the distance walked within 6 min. According to the literature, the test-retest reliability values for the TUG and the 6MWT were high for children with CP. The TUG also demonstrated adequate validity in children.

Transcranial direct-current stimulation

tDCS is the application of a low-intensity direct current on the scalp using two electrodes (anode and cathode). A sufficient amount of current penetrates the overlying tissues and reaches the structures of the motor cortex, modifying the neuronal membrane potential. Anodal stimulation enhances cortex excitability. The tDCS device (Soterix Medical Inc., USA) included two non-metallic sponge surface electrodes measuring 5 × 5 cm2 and moistened with saline solution. The children received anodal stimulation of the primary motor cortex. The anode was positioned over the primary motor cortex of the dominant hemisphere following the10-20 international system of electrode placement for electroencephalography and the cathode was positioned in the supra-orbital region contra lateral to the anode. The current was applied to the primary motor cortex for 20 minutes, during which the children remained seated. The tDCS device has a button that allows the operator to control the intensity of the current. Stimulation was gradually increased until reaching 1 mA and gradually reduced in the final10 seconds. For sham stimulation, the electrodes were positioned in the same manner and the stimulator was switched on for 30 seconds. This procedure gave the children in the control group the initial sensation, but they did not receive electrical stimulation for the remainder of the session. This is considered a valid control procedure in studies involving tDCS.

Progressive Resistance Training

Treatment was offered twice-weekly, 12-week progressive resistance training programme. Children with Cerebral Palsy completed their training on weights machines either singly or in pairs under the supervision of a physiotherapist. Children completed three sets of 10 to 12 repetitions of each exercise, with a 2-minute break between each set. This intensity of training (10–12 repetition maximum) is approximately equal to training at an intensity of 60% to 80% of one-repetition maximum. Children were instructed that they should feel as though they had worked 'hard', scoring at least a 5 on the 0 to 10 category of the Borg Perceived Exertion Scale, which was evaluated at the end of each session. When able to complete three sets of 12 repetitions of an exercise, the weight to be lifted was increased at the next session. Each child had a logbook detailing each exercise, the weight lifted, the number of repetitions, the number of sets completed, and the details of any injuries. After 12 weeks children were asked to take a break from resistance training, but to continue with all usual activities until the final testing session at 24 weeks. Exercises were individualized and targeted to address deficits identified by instrumented gait analysis collected with a 10-camera Vicon system (Oxford Metrics, Oxford, UK) supplemented by the physical examination of joint range of motion and muscle strength. Each child was prescribed four to six individualized exercises that would best address their problems in walking.

Functional strengthening of lower limbs

Sit-to-stand

The test was made according to Versuren *et al*. The child was placed on a stool with no back rest. Hips knees and feet were placed in 90°. Feet were kept parallel to hip. During all measurements the child held onto a50 cm stick to prevent support on thigh or stool. The child was requested to fully extend their hips and knees during standing before sitting again. Stand-sit was considered a full cycle, and the numbers of cycles fully carried through within 30 s were counted.

Lateral step-up

The children used a 20 cm stool. For each child the same height of stool was used before and after the training period. During the assessment the child stood next to the stool with straight hips and knees in the supporting leg. In the start of the test the leg to be tested was placed on the stool. The child was instructed to place the supporting leg (opposite to tested leg) fully on the stool with weight on legs, knees and hips straight before the supporting leg was placed on the floor again. Placement of the supporting leg on the stool and back on the floor was considered a full cycle. The number of completed cycles within 30 s was counted.

Half kneeling-standing

The children started the test in standing position with straight knees and hips and if necessary with one hand support. From this position the child took one large step forward to a position where one knee was touching the ground and then back to the initial position to perform one cycle. The number of completed cycles within 30s was counted. In all cases the right leg was tested first, regardless of whether the child had right- or left sided hemiplegia or diplegia.

CONCLUSION

Interventions targeting problems at body function and structure generally influenced this level without significant overflow to activity level and vice versa. Further research is required to determine more functional way would lead to better results in terms of gait characteristics and gross motor function in children with CP.

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