Case Study

Effect of Core Stability Exercise and Treadmill Training on Balance in a Patient with Cerebellar Ataxic Cerebral Palsy: A Case Report

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Abstract

Cerebral palsy (CP) is defined as a set of developmental illnesses that affect posture and mobility, causing activity restriction owing to abnormalities that are not progressive in the developing brain of the foetus or neonate. Children with cerebellar ataxic cerebral palsy often exhibit undeveloped or malformed cerebellar structures, resulting in challenges for the cerebellum to integrate the neural input required to control movement and balance smoothly. Patients with cerebellar ataxic cerebral palsy have difficulty in maintaining balance and trunk control which leads to difficulty in performing their activities of daily living and result in dependency. Thus, reporting cases like these is crucial to evaluate the impact of core stabilization intervention and treadmill walking on balance in a child having cerebellar ataxic cerebral palsy. A 7-year-old female child born at full term delivered via normal vaginal delivery with a birth weight of 2700 gm had no difficulties during antenatal, natal or postnatal phases. At the age of 6 years, mother noticed that the child had difficulty in standing and walking independently, she had difficulty in performing her activities of daily living independently. The patient underwent an 8 weeks intervention consisting of core stabilization exercise protocol and treadmill walking along with traditional physiotherapy intervention. The outcome measures included Paediatric Balance Scale for static balance and My Fitness Trainer (MFT)for dynamic balance. The patient showed significant improvement in both static as well as dynamic balance following the intervention. Thus, combined impact of core stabilization exercise protocol and treadmill walking can bring early effective changes on balance in a patient with cerebellar ataxic cerebral palsy.

Keywords: cerebellar ataxic cerebral palsy, core stability, treadmill training, balance, physiotherapy

Introduction

The term “cerebral palsy” (CP) refers to a set of developmental illnesses that affect posture and mobility, causing activity restriction owing to abnormalities that are not progressive in the developing brain of the fetus or neonate[1]. The motor impairment in CP is multifactorial, and it includes problems such as spasticity, dystonia, muscle contractures, bony deformities, coordination

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problems, loss of selective motor control, and muscle weakness[2].

In India, the total prevalence of cerebral palsy among 1000 children examined was 2.95 [95% CI 2.03-3.88]. Examination of different populations, including rural, urban, and mixed rural-urban, indicated prevalence rates of 1.83 [95% CI 0.41-3.25], 2.29 [95% CI 1.43-3.16], and 4.37 [95% CI 2.24-6.51], respectively[3].

Children with cerebellar ataxic CP often exhibit undeveloped or malformed cerebellar structures, resulting in challenges for the cerebellum to integrate the neural input required to control movement and balance smoothly[4]. Individuals having been diagnosed with cerebellar ataxic cerebral palsy exhibit cognitive deficits rather than contractures[5]. Additionally, they demonstrate deficiencies in coordination, balance, and fine motor skills. They exhibit central and peripheral instabilities, generalized muscle weakness, they also have poor coordination, poor balance, fine motor difficulties, axial and appendicular ataxia with inaccuracy of movement amplitude[6]. Children diagnosed with ataxic cerebral palsy have an unsteady stride, inadequate trunk stability, a broad stance while upright, swaying and stopping while walking, and possibly even taking backward steps to prevent falling[7]. They have reduced postural control because of inadequate equilibrium, defensive reactions, and an imbalance between agonist and antagonist muscles[8]. These children experience compromised trunk control due to diminished strength in abdominal and dorsal muscles which correlates with functional mobility[9].

Core stabilization exercises enhance the strength of muscles located in the abdomen, back, pelvis, and shoulders, facilitating the maintenance of trunk stability and control during both static and dynamic movements[10]. The muscles of the core stability area can be compared to a box, with the diaphragm serving as the roof, the pelvic girdle as the floor, the muscles of the spine and the gluteal region as the anterior and posterior sections, respectively[11]. The core stability training aims to improve the endurance and coordination of these core stability muscles as well as attain the best possible physical ability to preserve the spine's natural state throughout daily activities[12]. Children with ataxic CP benefit from core stability training in terms of standing and walking abilities, endurance, and balance.

Treadmill exercises elicit the dynamic, motion-oriented, and temporal dimensions of gait. It enhances the strength of the muscles in the lower limbs, promotes motor skill development, enhances functional capabilities, and triggers the mechanisms of neuromuscular regulation[13]. Consistent participation in treadmill programs yields comparable advantages, enhancing lower limb muscle strength, balance, and walking proficiency. This enhancement contributes to the amelioration of the dynamic aspect of balance.

There has been literature present on static balance but limited literature was available on dynamic balance whereas in the patients of cerebellar ataxic cerebral palsy dynamic component of balance is also equally affected. Therefore, there was a strong need to determine the effects of core stability exercise with treadmill training on static as well as dynamic components of balance in a patient with cerebellar ataxic cerebral palsy

Methodology

Case Presentation

We describe a case concerning a seven-year-old female child exhibiting a range of developmental abnormalities. The primary considerations regarding the child include functional deficits, coordination issues, involuntary movements and speech dysfluency. The mother has a documented history of miscarriage attributed to excessive workload during the initial first trimester. This patient was born at term following an uncomplicated gestation period of 9 months 7 days delivered vaginally with vertex presentation. Postnatally, the infant weighed 2700 grams and exhibited no delay in initiating a cry at birth, with no requiring neonatal intensive care unit (NICU) admission. The patient demonstrates a kyphotic posture during independent sitting, characterized by protracted shoulders and weight-bearing predominantly on the sacral bone rather than the ischial tuberosities. The patient employs their hands positioned beside them to stabilize and widen their base of support.

Additionally, the patient exhibited altered anthropometric measurements according to the

World Health Organization (WHO) guidelines. In the current assessment, the child exhibits a reduced head circumference of 53 cm, a stature of 103 cm, a mass of 16 kg, and a corresponding body mass index (BMI) of 13.7 kg/m², positioning her at the 50th percentile. Patient presented with involuntary movements in upper extremities while performing any task (intention tremors), titubation and squint present at left eye (esotropia) these symptoms were first noticed by the mother when the child was 3 years old. Maternal apprehensions regarding the child at this age pertain to deficits in functional activities (standing, walking, climbing stairs), performing activities of daily living (ADL's), maintaining balance and coordination and speech fluency.

Motor Milestones were delayed comparing normative time frames as shown in (Table 1) and Clinical Examination presented in (Table 2)

Regarding cerebellar ataxic cerebral palsy, patient had difficulty in maintaining balance and co-ordinations while performing any movement, when ambulated with support the patient had an ataxic gait pattern. The patient remains reliant on transfers, dressing-undressing, toileting, bathing and continues to be dependent on the caregiver.

Table 1: History of Developmental Milestones

Type	Milestone	Achieving age
Gross motor	Neck holding	6 months
	Rolling	7 months
	Crawling	14 months
	Sitting with support	12 months
	Sitting independently	5 years
	Standing with support	5 years
	Standing independently	Not yet achieved
Fine motor	Midline bilateral activities	5 months
	Grasping rattle	10 months
	Releasing rattle/object	12 months
	Manipulating toys	13 months
	Grasping cubes	15 months
	Grasping pencil/crayon	2.5 years
	Buttoning and unbuttoning	Not yet achieved
Social	Social smile	3 months
	Recognizing mother	4 months
	Smiles at mirror image	8 months
	Waves bye-bye	12 months
	Recognizes gender/ full name	6 years
	Goes to toilet alone	Not yet achieved
Language	Alerts to sound	2 months
	babbling	5 months
	Laughs loud	5 months
	Monosyllable	4 years
	Bisyllable	5 years
	1 to 2 words with meaning	5.5 years
	8 to 10 words with meaning	6 years
	Simple sentence	7 years
	Asks Questions	Not yet achieved

Table 2: Clinical Examination of the patient.

EXAMINATION	EXTREMITY	RIGHT SIDE	LEFT SIDE
Tone	Upper extremity	Normal	Normal
	Lower extremity	Normal	Normal
Reflexes	Upper limb	+2	+2
	Lower Limb	+1	+1
	Babinski	Positive	Positive
Range of Motion	Upper extremity	Complete actively	Complete actively
	Lower extremity	Complete actively	Complete actively
Manual Muscle Testing	Upper extremity	3/5	3/5
	Lower Extremity	3/5	3/5
	Upper and Lower Abdominals	2/5	2/5
	Lumbar extensors	3/5	3/5

PHYSIOTHERAPY INTERVENTION

The child was given Traditional physiotherapy intervention (TPI) (Table 3) for 30 minutes with Core stability intervention (CSI)[11] (Table 4) for 20 minutes and treadmill training for 10 minutes. The treadmill training regimen involved the patient walking on a treadmill at a pace set to more than the usual walking speed, for a 10-minute session with low-intensity walking and no inclination. The total treatment time being 1 hour with a gap of 5 mins within each protocol prescription for 8 weeks.

Table 3: Traditional Physiotherapy Intervention

PROBLEM LIST	PROBABLE CAUSE	GOAL FRAMED	PHYSIOTHERAPY INTERVENTION	VOLUME AND INTENSITY OF THE EXERCISE
Difficulty in standing independently	Reduced trunk control	Gain trunk control and independent transition	Sit to stand facilitation on a high stool progress to single leg sit to stand with multidirectional reach outs given in standing.	5 repetitions each set, 2 sets.
			Progress it to a low seated stool sit to stand facilitation.	5 repetitions each set, 2 sets.
Standing transitions	Reduced postural control and inactive base of support	Improve postural control and train into standing with activation of base	Standing training with a table in front for engaging the child in hand activities while therapist provides support at pelvis and knees.	5 mins standing, 2 mins relaxation, twice.
			Progress with narrow base of support with minimal support .	5 mins standing, 2 mins relaxation, twice.
			Task oriented activities are given to acquire weight shifts.	5 mins standing, 2 mins relaxation, twice.

Continue....

Walking transitions	Reduced balance	Improve balance	Stride standing (forward and backward stepping) while performing tasks to encourage weight shifts.	10 repetitions with 2 secs hold.
			Progressing to tandem standing	3 mins, 2 repetitions.
Difficulty walking independently	Inadequate trunk control and weakness in bilateral lower limbs	Gait training with minimal assistance	Walking in a parallel bar in forward, backward and sideways direction over the footprints while the therapist provided minimal support on the pelvis.	3 repetitions each.
			Progressing to walking with minimal/ no support.	3 repetitions each.
Difficulty in climbing stairs	Inadequate trunk control	Gain ground clearance and improve strength of lower limb muscles	Step up and down facilitation with stepper and support with railings.	10 repetitions each set, 2 sets.

Table 4: Core stability exercise program[11]

Week	Form of Exercise	The Volume and Intensity of Exercise
Week 1 and 2	Contracting abdominal muscles while lying in a supine position.	Three sets and 20 repetitions in each set.
	Contracting abdominal muscles while lying in a prone position.	Three sets and 20 repetitions in each set.
	Contracting abdominal muscles while lying in a squat position.	Three sets and 20 repetitions in each set.
Week 3	Contracting abdominal muscles while lying in a supine position with one leg stretched and the other bent at the knee and pressed against the abdomen.	Three sets and 20 repetitions in each set.
	Contracting abdominal muscles while lying in a prone position with one leg stretched and the body weight on the other leg which is bent at the knee.	Three sets and 20 repetitions in each set.
	Side lying bridge for each side of the body.	Six repetitions, a 10-s pause.
Week 4	Contracting abdominal muscles while lying in a supine position and pulling the limbs upward with arms and legs kept close.	Three sets and 20 repetitions in each set.
	In a squat position, one leg is raised and pulled outward and backward.	Three sets for each leg and 20 repetitions in each set.
	Trunk rotation while holding weights in each hand.	Three sets each part of the body and 20 repetitions in each set.

Week 5	Sitting on a Swiss ball and holding the abdomen in.	Three sets, 10 s.
	Squatting while the Swiss ball is on the shoulder.	Three sets and 15 repetitions for each set.
	Bringing up the arms and legs simultaneously in the prone position.	Three sets and 15 repetitions for each set.
Week 6	Bending 45 to the left or right.	Three sets for each side, 12 repetitions in each set.
	Bridging while shoulders and hands are on the floor and one leg is raised.	Three sets for each leg, 15 repetitions in each set.
	Contracting abdominal muscles while lying in a supine position on the Swiss ball.	Three sets, 12 repetitions in each set.
Week 7	Lying supine on the Swiss ball and rotating the trunk to the sides.	Three sets and 15 repetitions for each set.
	Doing the above exercise while holding weights in patient hands.	Three sets and 15 repetitions for each set.
	Side lying bridge with bringing up the leg.	Six repetitions for each side of the body and a 10-s pause.
Week 8	Lying supine on the Swiss ball and holding the abdomen in and bringing one leg up.	Three sets, 12 repetitions in each set.
	Raising the opposite arm and leg while squatting.	Three sets, 12 repetitions in each set.
	Bridge so that the feet are placed on the Swiss ball and raise one leg.	Three sets and a 15-s pause for each set.

OUTCOME MEASURES:

Used to assess Static and Dynamic Balance

1. Pediatric Balance Scale (PBS) (r= 0.86-0.98)[14].
2. My Fitness Trainer (MFT) Balance board[15].

Results

Outcome measures were evaluated following eight weeks of treatment. Table 5 presents a summary of the scale results obtained upon completion of the treatment period.

Table 5: Assessment of pre and post scores for outcome measures (PBS: Pediatric Balance Scale)

Outcome measure	Before treatment	After treatment
PBS	10	16
Balance System (Lateral component)	3.6 (Disproportionate stability)	3.0 (Improvable stability)
Balance System (forward and backward component)	4.5 (Bad stability)	3.8 (Disproportionate stability)

Interpretation: The child's static balance showed 60% improvement post treatment in Pediatric Balance Scale. Dynamic balance improvement in My Fitness Trainer (MFT) for lateral component was seen at 78% and for forward and backward component it was 80% compared to pre-assessment.

Discussion

This study reveals enthralling data that should be carefully considered and interpreted. The incorporation of traditional physiotherapy intervention protocol with core stability protocol and treadmill training appears to yield a positive effect

on balance and trunk control targeting the specific challenges individuals face with cerebellar ataxic cerebral palsy who experience deficits in function, balance and coordination. The specific tailored interventions emphasize the specific needs of the individuals with cerebellar ataxic cerebral palsy in achieving the therapeutic goals effectively.

By incorporating traditional physiotherapy protocol with core stability protocol and treadmill training, the study accentuates the probable advantages of concurrently improving static and dynamic aspects of balance. These results have the potential to provide valuable guidance to clinicians and therapists who specialize in this population, facilitating the development of more comprehensive and customized interventions.

The physiotherapy intervention presented in this research is a comprehensive approach to address cerebellar ataxic cerebral palsy in a seven-year-old patient exhibiting certain developmental abnormalities. All these interventions were customized to address particular components of the child's condition, with the goal of enhancing their overall static and dynamic balance. The Traditional physiotherapy intervention(TPI) could evoke the optimal lumbar-pelvic-hip chain mobility, good acceleration and deceleration, proper muscle balance and proximal stability, and corrects the postural alignments. In this study there was improvement seen in the pediatric balance score supported by the study of Ghaeeni et al. who evaluated the improvement of static balance in children with Down Syndrome by core stability exercise training. The Core stability intervention(CSI) enhances the ability to balance with progressive resistance training similar to weight-bearing exercises. This resulted in enhanced balance through the augmentation of muscle strength[11]. These exercises resulted in tonic activation of deep multifidus and other trunk muscles that have a greater percentage of type I (slow twitch) muscle fibers. In another study it suggests that core stabilization exercises could increase the body's proprioception, resulting in improved balance[10].

The treadmill training regimen involved the patient walking on a treadmill at a pace set to more than the usual walking speed, for a 10-minute session with low-intensity walking and no inclination helped in significantly improving the strength of lower extremity muscles, dynamic balance, and gait. In past literature with 6 months of treadmill training, evaluations revealed elevated mean peak torque, enhanced hamstring and quadriceps muscular strength, and improved dynamic balancing traits[16]. Treadmill training is proven to be beneficial for infants with Down Syndrome as a complement to regular physical therapy treatment approaches which can help in minimizing the delay in the initiation to walk. A higher step rate was obtained by increasing the intensity of treadmill training[17].

Pediatric physiotherapists play a crucial role in delivering essential services to children, leveraging their comprehensive understanding of early childhood development, physiological systems, and normative growth trajectories. Similarly, this tailored protocol had a positive impact on the static and dynamic aspects of the balance within 8 weeks of a protocol in a patient with cerebellar ataxic cerebral palsy.

Conclusion

In conclusion, this case report presents an inclusive intervention approach for individuals affected by cerebellar ataxic cerebral palsy, addressing both functional impairments and balance issues. Integration of traditional physiotherapy with core stability exercises and treadmill training yielded enhancements in both static and dynamic balance, emphasizing the efficacy of combining diverse physical therapy modalities. The significance of individualized treatment plans is highlighted, particularly for individuals with specific needs with cerebellar ataxic cerebral palsy, underscoring the imperative for personalized therapeutic interventions.

With the findings being promising, it is important to recognize the limitations of the study as it is a case study which can restrict the generalizability. Further investigation utilizing diverse samples and controlled designs is necessary to confirm and build upon initial findings.

Ethical clearance: Committee of the institute Dr. APJ Abdul Kalam, College of Physiotherapy, Pravara Institute of Medical Sciences. Registration number-COPT/MPT/2023/48.

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