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Efficacy of Balance Training Program in Cerebellar Atrophy: A Case Study

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ABSTRACT

Cerebellar atrophy leads to impaired balance, coordination, and gait, significantly affecting functional independence in children. This case report aimed to evaluate the effectiveness of a structured, goal-oriented physiotherapy protocol focused on static and dynamic balance training, co-ordination exercises, and strengthening in improving functional mobility in a 9-year-old child with cerebellar atrophy. A 9-year-old male with a confirmed diagnosis of cerebellar atrophy, history of birth asphyxia, and recurrent falls underwent an eight-week physiotherapy intervention. Pre-assessment revealed impaired coordination, increased muscle tone in upper and lower limbs, and markedly reduced balance with a Pediatric Balance Scale (PBS) score of 12/56. The intervention included upper and lower limb strengthening, core stabilization, Frenkel coordination exercises, and progressively challenging balance activities on unstable surfaces such as pillows, bean bags, mattresses, and wobble boards. Dynamic tasks included tandem walking and figure-of-eight walking. Post-intervention assessment was conducted using the same outcome measure. The child demonstrated notable improvements in postural stability, coordination, and functional balance. The PBS score increased from 12/56 pre-treatment to 32/56 post-treatment, indicating enhanced independence in activities of daily living. Clinical observations also showed better weight shifting, improved standing tolerance, and reduced gait instability. An individualized and structured physiotherapy protocol incorporating balance training on uneven surfaces, coordination exercises, and strengthening can significantly improve functional outcomes in children with cerebellar atrophy. Early and consistent physiotherapy intervention may enhance motor control, reduce fall risk, and improve overall quality of life in pediatric ataxia cases.

1. INTRODUCTION

Cerebellar atrophy is characterized by a progressive loss of cerebellar tissue within a posterior fossa of normal size, often with initially normal features [1]. Although children may reach developmental milestones, impairments in static and dynamic balance, coordination, and postural stability frequently manifest as key indicators of cerebellar involvement [2]. A decrease in muscle tone, commonly observed in affected individuals, supports the cerebellum's role in maintaining muscular tone [2]. As a central regulator of motor control, cerebellar damage leads to cerebellar ataxia (CA), a condition marked by movement dysfunction [3]. Early identification and timely intervention are crucial for managing symptoms and improving overall patient health [4].

Cerebellar atrophy clinically presents with varied symptoms, primarily involving poor motor control and impaired coordination [1] Ataxia, the hallmark of cerebellar dysfunction, results in unsteadiness and a loss of coordination that affects trunk stability, limb movement, and gait [5] To identify hereditary forms such as Friedreich's ataxia and spinocerebellar ataxias (SCAs), genetic testing is an essential diagnostic tool [2] The causes of cerebellar atrophy are broadly classified into non-genetic factors including infections, immune processes, toxins, tumors, and vascular incidents—and genetic factors encompassing chromosomal abnormalities, single-gene mutations, mitochondrial dysfunctions, and metabolic disorders [1]

Damage to the cerebellum impairs its core function of integrating sensory input with motor

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commands to ensure precision and coordination [3] Depending on the location and severity of cerebellar damage and the underlying cause, symptoms may vary, including disruptions in balance, gait, cognition, and fine motor coordination [5] These impairments can hinder basic daily tasks and increase fall risk, significantly affecting quality of life and independence [4].

Physiotherapy, particularly targeted balance and strength training, can improve trunk stability, walking ability, and motor control [4] Exercises focusing on the core and lower limbs enhance posture, reduce fall risk, and promote endurance. Rehabilitation plans must be individualized, aligning with each patient's functional limitations, preferences, and personal goals, ensuring meaningful improvements in mobility and daily functioning [4]

2. MATERIALS AND METHODS

This study adhered with all ethical standards and received approval from the Krishna Vishwa Vidyapeeth Deemed-to-be University, Karad, under reference number [KVV/IEC/04/2025]. Informed consent was obtained from the participant using a volunteer consent form that clearly outlined the purpose of the research, potential risks and benefits,confidentiality provisions, and participants' rights. The study was conducted with ethical principles of the Declaration of Helsinki, ensuring that participant rights, safety, and well being were prioritized throughout the study's design, procedures, and confidentiality measures.

2.1. Case Presentation

A 09-year-old male came to the hospital with a complaint of inability to stand without support, weakness in lower limbs. His guardian reported birth history which specified that birth cry was absent, patient had history of low birth weight, birth asphyxia and patient was admitted in NICU for 7 days where he had his first episode of seizure.

MRI brain was done at 2 years of age which showed multifocal cortical T2/FLAIR hyperintensities noted in bilateral supratentorial brain parenchyma- vasogenic oedema- possibilities include post ictal oedema and changes of hypoxia ischemic encephalopathy which significantly shows neuro-diagnosis of Cerebellar atrophy.

Now patient has no recent history seizures but falling frequently when trying to stand. And patient is complaining of after weakness in both upper, lower limbs and core with and having an ataxic gait pattern. Following the assessment, patient underwent 8 weeks of physiotherapy protocol.

Before the examination, the patient's guardian was briefed about the process, and their consent was obtained. On the day of the assessment, Paediatric Balance Scale (PBS) was used as an outcome measure which showed score 12/56. The sensory examination on the patient showed intact sensations. During the motor examination, the tone assessment indicated the presence of grade 2+ tone (tone grading scale) in lower limbs and 3+ tone in upper limbs Table 1. An evaluation of the coordination showed impaired finer to finger and finger-to-nose (Equilibrium test for co-ordination). Gait examination revealed inability to walk due to imbalance with ataxic type of gait pattern.

The patient underwent investigation of MRI Brain, which showed there is multifocal cortical T2/FLAIR hyperintensities noted in bilateral supratentorial brain parenchyma- vasogenic oedema- possibilities include post ictal oedema and changes of hypoxia ischemic encephalopathy (Fig 1.)

Table 1. Assessment of muscles of UL and LL

Tone	Left	Right
Upper Limbs	3+	3+
Lowe Limbs	2+	2+

Fig1. MRI Scan showing cerebellar atrophy

2.2. Physiotherapy Exercise Programme

Methodology outlines the design structured goal-oriented physiotherapy intervention for a case study to evaluate the efficacy of balance training using uneven surfaces such as pillows and bean bags for Eight weeks Table 2. Goal is to assess the impact of this training on improving balance and functional mobility.

Table 2. Structured physiotherapy intervention

For UL strengthening	• **Active ROM** • **Wall Pushups** • **Grip strengthening**
For LL strengthening	• Active ROM • Squats • Runners stretch • Sit ups
For core strengthening	• Pelvic bridges • Cobra stretch • Cat and camel pose • Crutches
For static balance	• Sit to stand • Romberg's • Tandem standing • Standing on pillow • Standing on bean bags • Standing on mattress • Wobble board training
For dynamic balance	• Tandem walking • Walking in a figure of eight
For co-ordination	• Frenkel's exercises • Finger to finger • Finger to nose • Finger to therapist fingers • Drawing a circle

3. RESULTS

Outcome measure included Pediatric Balance Scale. Pre and post treatment scores were recorded Fig 3. The patient showed significant independence in ADL.

The study showed that:
PBS score before the treatment regimen was 12/56.
PBS score after the treatment regimen was 32/56.

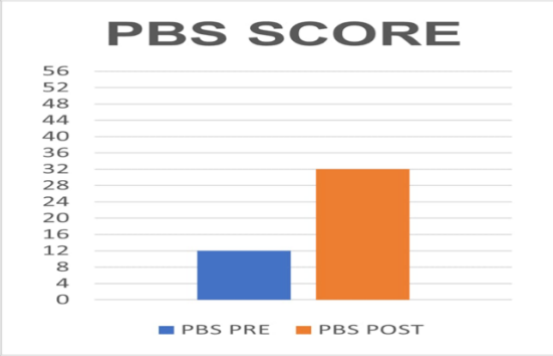

Fig 3. PBS Score (PRE and POST treatment)

4. DISCUSSION

Cerebellar atrophy results in progressive degeneration of the cerebellum, leading to a significant decline in motor function and a subsequent impact on an individual's capacity to perform daily tasks [6] Beyond motor control, the cerebellum contributes to cognitive processing and emotional regulation, making cerebellar atrophy a complex disorder with wide-ranging consequences [7]. The manifestation of symptoms varies among individuals, depending on the severity, location of cerebellar damage, and underlying etiology, necessitating personalized rehabilitation strategies [6]. Managing symptoms such as fatigue and spasticity requires a comprehensive and proactive therapeutic approach [7].

In this study, a 9-year-old male with cerebellar atrophy and ataxia demonstrated improvements following an eight-week physiotherapy program that emphasized balance training on unstable surfaces. This approach enhanced sensory integration and postural control by challenging the somatosensory, vestibular, and proprioceptive systems [7]. Core and lower limb strengthening contributed to better responses to both static and dynamic balance demands. Additionally, exercises such as Frenkel coordination drills, including finger-to-nose tasks, supported improved limb control and reduction in dysmetria [6]. Initiating physiotherapy at an early stage of ataxia, even with mild symptoms, is critical for optimizing outcomes and functional independence [8].

Compared to other studies focusing on ataxia secondary to different neurological conditions, this case study highlights the efficacy of targeted balance and coordination training in improving motor performance and quality of life in pediatric cerebellar atrophy [7].

5. Conclusion

This case report highlights the effectiveness of a structured physiotherapy protocol, including Static as well as dynamic balance exercises along with a co-ordination training in a 9-year-old patient with cerebellar atrophy. This Study demonstrated that balance training on uneven surfaces combined with co-ordination exercises can significantly improve functional balance, postural stability along with the static and dynamic stability. This approach has also helped to enhance quality of life and ADL. Physiotherapy plays a vital role in managing cerebellar ataxia, improving balance, gait, and overall function with a tailored exercise program, designed by a physiotherapist, can help patients reach their full potential, minimize problems, and enhance their overall health and well-being.

Conflict of Interest

The authors declare that there are no conflicts of interest related to the publication of this case study.

Ethics Committee

This study adhered with all ethical standards and received approval from the Krishna Vishwa Vidyapeeth Deemed-to-be University, Karad, under reference number [KVV/IEC/04/2025].

Author Contributions

Study Design, DK and MM; Data Collection, DK and SRS; Statistical Analysis, DK; Data Interpretation, MM and SRS; Manuscript Preparation, DK, MM and SRS; Literature Search, DK, MM and SRS. All authors have read and agreed to the published version of the manuscript

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