Effect of Goal oriented training in improving balance and gait velocity in a child with Pediatric-onset Multiple sclerosis- a case report

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ABSTRACT

Objectives: To evaluate the effect of goal-oriented physiotherapy on balance and gait velocity in a child with pediatric-onset multiple sclerosis.

Background: POMS is rare, particularly when onset occurs below 10 years of age, and may follow a more aggressive inflammatory course than adult MS, leading to balance deficits, gait distrubances, and decreased functional mobility. There is limited evidence regarding rehabilitation in pediatric MS population.

Results: Functional improvements were observed during both rehabilitation periods after four weeks of intensive physiotherapy (two sessions/day). Berg Balance Scale scores improved from 42 to 50 in 2023 and from 14 to 24 in 2025. In 2023, gait velocity improved from 0.19 to 0.27 m/s, and 10-Meter Walk Test time improved from 51 to 36 seconds. Performance in the Sit-to-Stand test and 9-Hole Peg Test also showed measurable improvement.

Conclusion: Goal-oriented, task-specific physiotherapy led to clinically meaningful improvements in motor function, postural stability, and mobility in a child with POMS, suggesting its feasibility in pediatric MS.

INTRODUCTION

Multiple sclerosis (MS) is a chronic inflammatory disorder that primarily affects the central nervous system (CNS) and is characterized by immune dysregulation, multifocal demyelination, axonal damage, and gliosis. (1) Genetic factors, particularly the HLA-DRB1*15:01 allele, may combine with environmental triggers such as Epstein–Barr virus infection, causing abnormal T-cell and B-cell

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responses that disrupt the blood–brain barrier and result in plaque formation in white matter regions, including the periventricular areas, optic nerves, and spinal cord. (2)

Although MS mostly affects adults, pediatric-onset MS presenting below the age of six is extremely rare and represents a very small proportion of MS cases. In children, the disease may follow a more inflammatory course with early brainstem or cerebellar involvement and may present with ataxia, optic neuritis, or hemiparesis. (4)

In addition to medical treatment, physiotherapy has been studied as a rehabilitation approach in MS. A systematic review of 13 studies evaluated interventions such as exercise therapy, multidisciplinary rehabilitation, functional electrical stimulation, botulinum toxin combined with stretching, and body-weight supported treadmill training. Most studies reported improvements in walking ability, muscle strength, balance, or quality of life. However, the overall evidence was limited due to small sample sizes, high dropout rates, and methodological limitations, highlighting the need for larger, well-designed randomized controlled trials to confirm the effectiveness of physiotherapy and identify optimal rehabilitation strategies. (5)

CASE PRESENTATION:

A 4-year-old girl with a known history of seronegative recurrent central nervous system inflammatory disorder, who had previously been admitted to our center for recurrent right-sided hemiparesis and right focal seizures with impaired awareness, presented again with seizure recurrence. Her earlier neuroimaging had consistently shown large, confluent demyelinating lesions involving the left fronto-parietal and temporal regions, affecting the subcortical, deep, and periventricular white matter, as well as the left thalamus, left external capsule, and right middle cerebellar peduncle. These lesions had demonstrated marked responsiveness to corticosteroid therapy and maintenance rituximab, with significant reduction in lesion size and corresponding clinical stability between episodes. She was now brought to the emergency department with 2–3 episodes of left motor seizures progressing to bilateral tonic–clonic seizures. According to her mother, the child had also been experiencing intermittent fever for the past one to two months, accompanied by recurrent upper respiratory tract infections. In November 2022, she initially presented with right hemiparesis and aphasia and recovered fully within one month following intravenous immunoglobulin therapy, with no residual deficits. In February 2023, she experienced a relapse of right hemiparesis associated with facial weakness and aphasia and was treated with pulse-dose corticosteroids and intravenous immunoglobulins; her speech gradually improved over the following two months, supported by intravenous rituximab therapy, although she

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was left with residual right hemiparesis. In November 2023, she had a single episode of right focal motor seizure with impaired awareness. Repeat neuroimaging demonstrated regression of the left parieto-occipital lesion. She received her third maintenance dose of rituximab (300 mg) on 10/12/2024. Subsequently, in June 2025, she received her fourth maintenance dose of rituximab (300 mg) on 14/06/2025. On admission, vital signs were stable except for tachypnea, with a respiratory rate of 32 breaths/minute, pulse rate of 112 beats/minute, blood pressure of 120/60 mmHg, and oxygen saturation of 99% on room air.

Table 1. Clinical findings of the patient with pediatric-onset multiple sclerosis

Clinical domain	**Key aspects**	**2023**	**2025**
Neurological examination	Right hemiparesis Difficulty in fine grasp with right upperlimb Balance impairment Gait impairment	Right hemiparesis Difficulty in fine grasp with right upper limb Balance impairment Gait impairment	Poor bronchopulmonary hygein Hyperthermia Right hemiparesis Difficulty in grasping with right upperlimb Difficulty in standing without support Balance impairment Gait impairment
Functional Assessment Tools	Expanded Disability Status Scale (EDSS) Pediatric MS Severity Score (Ped-MSSS) Multiple Sclerosis Rating Scale-Revised (MSRS-R)	4 (significant disability) 8 (very agressive disease) 9 (Mild disability)	6 (requires unilateral support) 9 (very aggressive disease) 16 (Moderate disability)

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Laboratory Investigations	Hemoglobin (g/dL) MCV (fL) MCH (pg) TLC (/µL) Eosinophils (%)|	10.6 ↓ 68 ↓ 19 ↓ 11,700 ↑ -	10.7 ↓ 67 ↓ 20 ↓ 12,100 ↑ 15 ↑
Radiological Imaging	Demyelination Signal Change Volume Loss Additional Findings	Present Mild reduction Mild None significant	Present Moderate reduction Increased Collections present; possible infection
Clinical diagnosis	Multiple sclerosis		

Image 1: Goal oriented training (2023)

Image 2: Standing (2025)

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PHYSIOTHERAPY INTERVENTIONS

Table 2. Physiotherapy protocol

Therapeutic intervention	**Frequency (1 set per session; 2 sessions per day)**	**Duration**	**Outcome measurement**
Chest physiotherapy	-	10 minutes/ session	-
Strength training	10 repetitions	10 mins/ session	Manual muscle testing(MMT)
Swiss ball exercises	10 repetitions	10 mins/session	MMT, Berg balance sacle (BBS)
Scooter board exercises	15 repetitions	10 mins/session	Hand function tests
Balance exercises	10 repetitions /exercise	10 mins/session	Berg balance scale(BBS)
Functional re-education	10 repetitions /task	10 mins/session	5 repetition sit to stand test(5 STS test)
Task specific exercise	15 repetitions /task	20 mins/ session	Barthel index
Gait training	-	10 mins/ session	10-Meter Walk Test(10 MWT)

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OUTCOMES and RESULTS

Table 3. Outcome measurements at baseline and after four weeks of intervention in 2023 and 2025.

	2023				**2025**			
	Base line		**After 4 weeks**		**Baseline**		**After 4 weeks**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Muscle tone (MAS)	UL- Hypotonia LL- 1	UL and LL - 0	UL- Hypotonia LL- 1	UL and LL -0	UL- Hypotonia LL- 1	UL and LL -0	UL- Hypotonia LL- 1	UL and LL -0
MMT		4/5		4+/5		3+/5		4/5
VCG	4		4		2		2	
9-Hole Peg Test (arm dexterity)	Could'nt be assesed	45 seconds	Could'nt be assesed	30 seconds	Could'nt be assesed	60 seconds	Could'nt be assesed	51 seconds
BBS	42/56		50/56		14/56		24/56	
5 STS test	54 seconds		40 seconds		Could'nt be assesed		60 seconds	
10 MWT	51 seconds		36 seconds		Could'nt be assesed		59 seconds	
Gait velocity	0.19 m/s		0.27 m/s		Could'nt be assesed		0.16 m/s	

The results showed that in 2023, muscle tone remained unchanged, with right upper limb hypotonia and grade 1 tone in the right lower limb, while the contralateral upper and lower limbs showed normal tone after four weeks of intervention. Manual Muscle Testing (MMT) improved to 4+/5, and Voluntary Control Grading (VCG) was maintained at 4. Hand dexterity improved, as indicated by a decrease in 9-Hole Peg Test time from 45 to 30 seconds.

Balance and mobility also showed progress in 2023, with the Berg Balance Scale (BBS) increasing from 42/56 to 50/56, the 5-repetition Sit-to-Stand (5 STS) time decreasing from 54 to 40 seconds, the 10-Meter Walk Test (10MWT) improving from 51 to 36 seconds, and gait velocity increasing from 0.19 m/s to 0.27 m/s.

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In 2025, baseline status was poorer, with BBS at 14/56, VCG at 2, slower 9-Hole Peg Test times (60 seconds), and reduced strength (MMT 3+/5). After 4 weeks of intervention in 2025, moderate improvements were observed: MMT increased to 4/5, 9-Hole Peg Test time was 51 seconds, BBS increased to 24/56, 10MWT was 59 seconds, and gait velocity was 0.16 m/s after intervention, although overall performance remained below 2023 levels.

DISCUSSION

The present case highlights the effectiveness of goal-oriented physiotherapy in improving balance and gait velocity in a child with POMS, a rare and highly inflammatory form of the disease. Pediatric MS is uncommon, and onset below six years of age is extremely rare and is frequently associated with relapses and greater lesion burden, particularly involving cerebellar and brainstem regions, significantly affecting balance and gait function. (4)

MS results from immune-mediated demyelination and axonal injury, which may impair neural conduction and contribute to weakness, coordination deficits, and reduced functional mobility. These impairments contribute to activity limitations and participation restrictions, reflected in this case through reduced BBS scores, prolonged sit-to-stand time, decreased gait speed, and difficulty with daily activities. (1,2)

Rehabilitation plays a crucial role in managing functional deficits in MS. Campbell et al. reported that physiotherapy interventions may improve walking ability, balance, muscle strength, and quality of life in MS, although evidence quality was limited. (5) The current case aligns with these findings, demonstrating clinically meaningful improvements in balance, functional mobility, upper limb dexterity, and gait speed following four weeks of structured intervention.

Goal-oriented, task-specific training is grounded in motor learning principles and emphasizes repetitive practice of functional tasks to support motor relearning and neuroplasticity. Context-specific activities such as sit-to-stand, balance tasks, and gait training facilitate cortical reorganization and improve motor control. Task-oriented training has been shown to improve functional mobility and independence in MS by enhancing motor relearning and reducing compensatory movement patterns. (6,7)

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Balance impairment is common in MS and contributes to fall risk and reduced participation. Programs incorporating dynamic balance training, core stability exercises, and functional re-education significantly improve postural control. (8) The BBS improvements observed in this case support enhanced postural stability following intervention.

Gait dysfunction in MS is multifactorial, involving muscle weakness, spasticity, fatigue, and impaired coordination. Task-specific gait training and repetitive walking practice have demonstrated improvements in 10-Meter Walk Test and functional ambulation in MS. (9)

The improvement in upper limb dexterity and muscle strength further supports the role of repetitive functional practice in motor recovery. Resistance training in MS increases muscle strength without exacerbating fatigue or disease activity, contributing to improved functional performance. (10)

CONCLUSION

This case report suggests that goal-oriented and task-specific physiotherapy may produce clinically meaningful improvements in balance, gait velocity, functional mobility, and upper limb function in a child with pediatric-onset multiple sclerosis. Following four weeks of structured intervention, the patient showed measurable gains in Berg Balance Scale scores, sit-to-stand performance, gait speed, and hand dexterity, indicating enhanced postural control, muscle strength, and functional independence.

The findings support the feasibility of repetitive, functional, and individualized training in promoting motor relearning and functional independence in pediatric demyelinating disorders. Early initiation of rehabilitation, along with strong family support and good treatment adherence, may further enhance functional outcomes.

Overall, this case reinforces the importance of early, intensive, and task-specific rehabilitation in managing functional deficits in pediatric multiple sclerosis and highlights the need for larger controlled studies to establish standardized rehabilitation protocols for this population.

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LIMITATIONS

Despite the positive outcomes, this case has certain limitations. The absence of long-term follow-up limits interpretation regarding the sustainability of functional improvements. Concurrent medical management may have influenced recovery and should be acknowledged as a limitation. Different baseline severity in 2023 and 2025 makes direct comparison between the two rehabilitation periods difficult. As this is a single-case report, the findings cannot be generalized to all children with pediatric-onset multiple sclerosis. Nevertheless, the results provide preliminary evidence supporting the feasibility and clinical benefit of goal-oriented physiotherapy in pediatric MS.

RECOMMENDATIONS

Although the results cannot be generalized due to the single-case design and short follow-up period, this report highlights the clinical feasibility and potential effectiveness of goal-oriented physiotherapy in pediatric multiple sclerosis. Further large-scale, long-term studies are required to establish standardized rehabilitation protocols and to determine the sustainability of functional improvements in this population.

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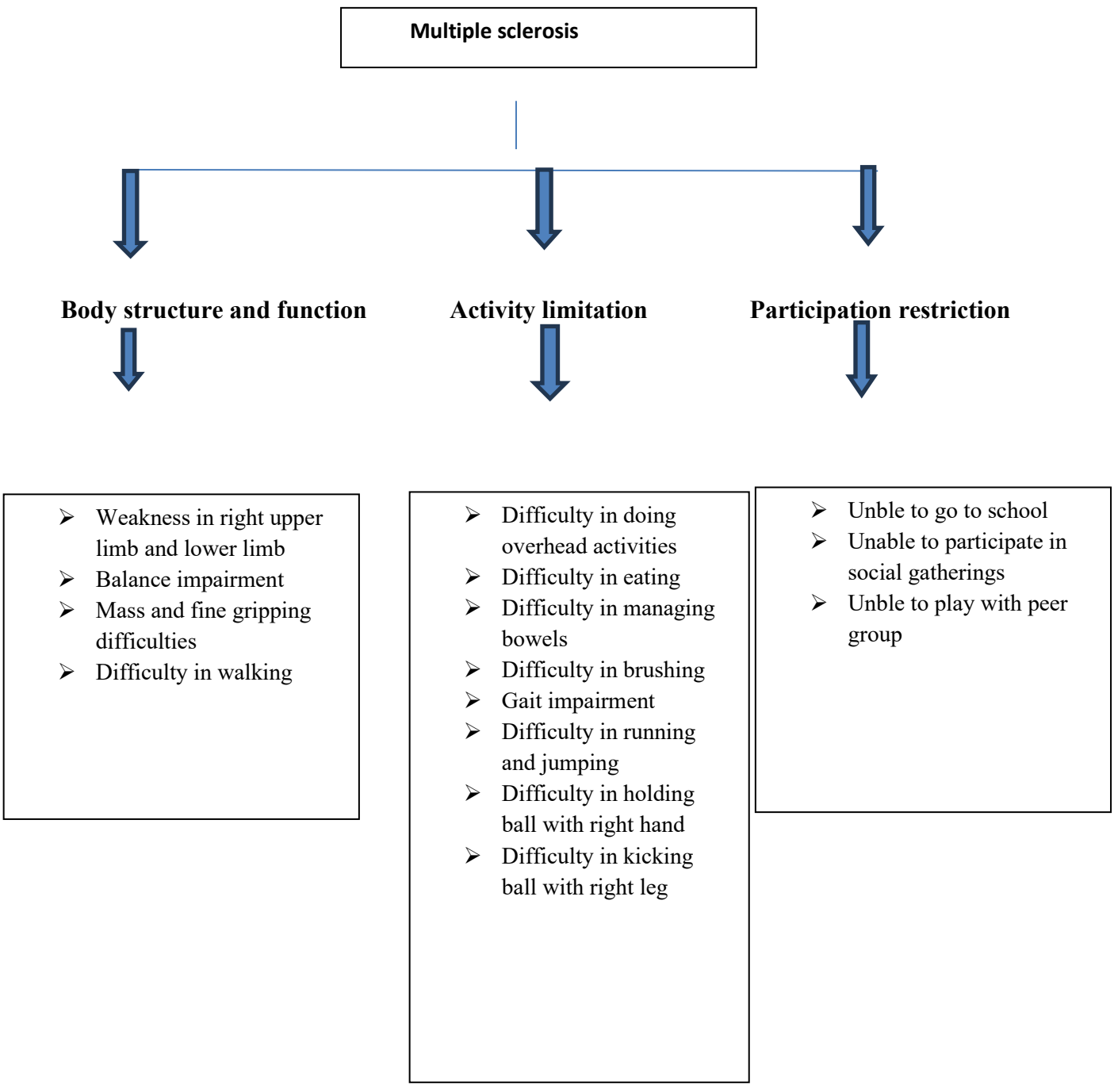
International Classification of Functioning, Disability and Health (ICF) model:

ICF CLASSIFICATION



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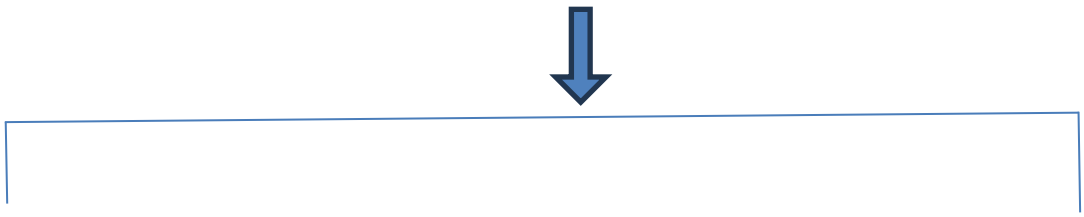

Environmental factors

Facilitators: medication timing, supporting family,

Planned activities with proper rest breaks,

Motivated to participate in rehabilitation

Barriers: fatigue with sustained activity

Personal factors

Child (4 yrs)

Female

Good Cognitive level

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CONSENT FORM

I _____ {name} voluntarily give consent to participate in the study entitled **"Effect of goal oriented training in improving balance and gait velocity in a child with Pediatric-onset Multiple sclerosis- a case report."** In doing so I affirm that:

I have been given full information in my native language about the study and have understood the purpose and nature of the study and the potential risks to me resulting from my participation in the study.

I have been given ample opportunity to ask questions, which have been answered to my satisfaction.

I understand that my participation in the study is purely voluntary and that unwillingness/refusal to participate will not adversely affect the medical care due to me.

I have been assured that there is no additional medical expenditure to be incurred by me on account of my participation in the study.

That I faced no coercion to sign this consent form.

I have been informed that notwithstanding my signing this consent, I can withdraw from the study at any point of time, without it compromising in any way, the medical care to which I am entitled.

Signature of patient	Signature of Witness	Signature of Investigator
Name of patient	Name of Witness	Name of Investigator
Date	Date	Date
Place	Place	Place

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