

# Efficacy of the Structured Physiotherapeutic Program in Patients with Cerebellar Ataxia: Impact on Severity, Balance, and Motor Recovery in Indian Population

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## ABSTRACT

**Background:** Cerebellar ataxia is a progressive neurodegenerative condition that affects motor coordination, leading to challenges in balance, movement, and daily activities. With limited pharmacological treatments available, physical therapy has emerged as a promising approach to manage symptoms and enhance functional abilities in individuals with cerebellar ataxia.

**Purpose:** To investigate the efficacy of a structured physiotherapeutic program in decreasing the severity of ataxia and improving balance, functional independence, functional sitting abilities and gait velocity in patients affected with cerebellar ataxia in Indian rural population.

**Methodology:** 26 patients of cerebellar ataxia, aged 18–65 years were included as per selection criteria and were randomly divided into two equal groups, Group A(n=13) and Group B(n=13). All the patients were assessed for severity of cerebellar ataxia, balance, functional status along with gait velocity using SARA, BBS, m-FIM and FIST respectively. Group A received Structured Physiotherapy Program whereas Group B received Home Based Exercise Regimen. Both the groups were given interventions for a total of 4 weeks, with 6 sessions per week.

**Results:** The results showed statistically significant difference in scores of SARA and FIST in group A (t value 3.054 and -4.052 respectively) as well as in group B (2.555 and -2.399 respectively) whereas statistically significant difference was found in the scores of BBS, m-FIM and Gait velocity in group A only.

**Conclusion:** Structured physiotherapeutic program and home based exercise regimen, both were effective, in decreasing the severity of ataxia and improving functional sitting abilities in patients with cerebellar ataxia. But home based exercise regimen was more efficacious in improving functional sitting abilities. Further, only structured physiotherapeutic program was only effective in improving motor recovery in patients with cerebellar ataxia belonging to rural areas.

**Keywords:** Cerebellar ataxia, Balance, Home based exercises, Motor recovery, Physiotherapy.

## INTRODUCTION

Cerebellar ataxia, a neurological disorder affecting the cerebellum, has a major impact on the functional independence of patients

with degenerative cerebellum. It is a common consequence of various neurologic diseases, with more than 400 types having been described. According to National

Institute of Neurological Disorders and Stroke (NINDS), cerebellar ataxia is characterized by a lack of coordination and control of voluntary movements, including difficulty with balance, walking, and fine motor tasks such as writing or using utensils.

The prevalence of ataxia varies globally, with estimated occurrence rates of 2.7/100,000 in dominant hereditary cerebellar ataxia and 3.3/100,000 in recessive hereditary cerebellar ataxia respectively.<sup>[1]</sup> Spinocerebellar ataxias (SCAs) represent a major subset of cerebellar ataxia, with SCA3 being the most common type worldwide, though SCA2 is generally considered the commonest one in India.<sup>[2]</sup> Epidemiological studies have indicated varying prevalence rates of cerebellar ataxia in different populations, such as a prevalence rate of 8.29 patients per 100,000 persons in Korea.<sup>[3]</sup> As far as epidemiology of cerebellar ataxia in India is concerned, Rengaraj R. et al. (2005) conducted a study of prevalence of cerebellar ataxia in two villages in Indian state of Tamil Nadu. The prevalence of SCA1 was high (7.2%) in ethnic Tamil community.<sup>[4]</sup>

Cerebellar ataxia progressively impairs posture, equilibrium, limb movement, oculomotor control, and gait. This debilitating condition exhibits progressive worsening of motor coordination or ataxia resulting in difficulties with balance, walking, and fine motor tasks. In walking, ataxia is evident by a shortened stride length, high step pattern, and decreased push-off and veering. The gait deviations have been closely linked to the severity of the individual's balance deficits. These impairments not only affect the lives of patients, but also place a significant burden on their families and caregivers. The economic impact of cerebellar ataxia is substantial, as the condition requires continuous management and support. Unfortunately, there are no disease-modifying pharmacological treatments available for cerebellar ataxia. As a result,

physical therapy interventions have become the primary therapeutic options.

Previous literature suggested that intensive physical therapy focusing on balance, gait, and strength training in hospital and home for patients with degenerative cerebellar ataxia can improve ataxia, gait ability, and activity of daily living.<sup>[5]</sup> Further, balance training and aerobic training were also effective interventions in reducing the severity of ataxia in these patients.<sup>[6]</sup>

As previous published literature on interventions for cerebellar ataxia is limited in the context of small sample sizes, short survey periods, and lack of control groups, there is a need for specific physiotherapy management strategy tailored to address the challenges faced by individuals with cerebellar ataxia. In India, the patients with cerebellar ataxia, especially in rural areas, have lack of awareness and limited resources to receive the effective treatment. Rehabilitation specialists are often unable to reach faraway places to incorporate supervised daily therapy sessions, which often seem to be necessary in the management of patients affected with cerebellar ataxia.

This research study endeavours to enhance the functional outcomes of individuals with cerebellar ataxia in their daily activities by mitigating the severity of ataxia, improving balance, independence, and motor recovery, while considering the constraints of awareness, resources, and financial limitations within the Indian rural population. Thus, there is a dire urgent need to assess the effectiveness of home based therapy in comparison to structured supervised program in Indian rural population.

## **MATERIALS & METHODS**

Twenty six patients with cerebellar ataxia, aged 18-65 years ( $45.6 \pm 11.5$ ), both males and females, affected for a duration of 3 months to 11 years, with molecular diagnosis or at least three generation affected, of recessively or dominantly inherited cerebellar ataxia/Definitive genetic

diagnosis of SCA (SpinoCerebellar Ataxia)/Acquired or Degenerative cerebellar ataxia treated were included in the study. The criteria for inclusion comprised of having Mini Mental State Examination (MMSE) score >22, mobility ranging from minimum score of 2 for question 1 'gait' of Scale for the Assessment and Rating of Ataxia (SARA) and minimum score of 4 for item – 'transfers bed, chair, wheelchair of M-Functional Independence Measure (m-FIM). All the patients were able to stand and take steps independently without any orthosis and assistive devices. The patients were excluded if they were having concomitant brain lesions, terminal chronic disease, uncontrolled hypertension, unstable angina, pregnancy, another medical condition that impacts on mobility, significant cognitive impairment limiting ability to give informed consent. The patients who underwent major orthopedic surgery in last six months, already completing greater than 3 hours per week lower body physical therapy, currently enrolled in another clinical trial, need for immediate intensive intervention for safety measures, received botulinum injection for spasticity management and with multiple system involvement, other movement disorders e.g. Huntington's disease, etc were also excluded.

Before the commencement of the study, ethical clearance was obtained from the Institutional Ethical Committee of University College of Physiotherapy, Faridkot. Thirty seven patients were initially screened in the IPD and OPD of Guru Gobind Singh Medical College and Hospital, Faridkot and University College of Physiotherapy, Faridkot, Punjab; 28 patients fulfilled the selection criteria and were enrolled in the study. But later on, two subjects dropped out and 26 patients completed the study. After obtaining their written informed consent, the selected patients were assessed for homogeneity for age, height, weight, BMI and MMSE score. Further, the patients were randomly divided into two equal groups, group A (n=13) and

group B (n=13). Group A was administered Structured Physiotherapeutic Program, whereas in group B, home based exercise regimen was given.

The patients in both the groups were assessed for severity of ataxia, balance, functional independence, functional sitting abilities and walking speed using Scale for the Assessment and Rating of Ataxia (SARA), Berg Balance Scale (BBS), m-Functional Independence Measure scale (m-FIM), Function in Sitting Test (FIST) scale and Gait velocity respectively. The total intervention duration for both the groups was 4 weeks and baseline assessment were done before starting the intervention and final assessment was conducted at 4th week post intervention.

The Scale for the Assessment and Rating of Ataxia (SARA) is a tool for assessing ataxia and is made up of 8 items. It has eight categories with accumulative score ranging from 0 (no ataxia) to 40 (most severe ataxia). Once each of the 8 categories has been assessed, the total is calculated to determine the severity of ataxia.

The Berg Balance Scale (BBS) is used to objectively determine a patient's ability or inability to safely balance during series of predetermined tasks. It is a 14 item list with each item consisting of a five- point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4, the highest level of function.

The Function in Sitting Test (FIST) is a 14 item, performance-based, clinical examination of sitting balance. The patients were asked to perform basic, everyday activities in a seated position and their performance was scored using 0-4 point ordinal scale (ranging from 0 indicating dependent and 4 indicating independent).

The M-Functional Independence Measure (m-FIM) is subset of FIM. The m-FIM evaluates a person's ability to perform motor activities of daily living. Items include performance in self-care, sphincter control and mobility. It consists of 13 items, each assessed against a 7-point ordinal scale which ranges from maximum score of 91

(complete independence) and minimum of 13 (complete dependence).

For measuring gait velocity, the patients were instructed to walk the middle 8 meters of 10 meters and were timed by a chronometer. The first and last meters, considered as warm-up and deceleration

phases, respectively, were not included in the calculation. Each patient performed the task twice after one non timed practice trial. The final score was the time in seconds of the quicker of two timed trials.

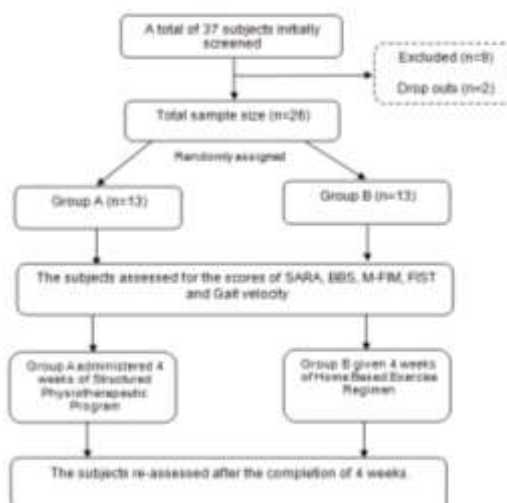


Figure 1: The flowchart depicting the procedure of the study

## Interventions

### Structured Physiotherapeutic Program

[7]:

The patients were administered six therapy sessions per week for a total duration of 4

weeks with each therapy session lasting for 60 minutes, with appropriate rest intervals. The detailed description of exercise intervention in this program has been included in Table 1.

Table 1: Description of Structured Physiotherapeutic Program.

Rationale	Treatment activities
Week 1 To improve upper limb and trunk muscle strength  Promote limb coordination and gaze stabilization (continued in every week)	Core stability: Static abdominals, partial curls, and trunk rotations. PNF: Rhythmic initiation and active-assisted symmetrical UL and LL, D1, and D2 flexion-extension along with pelvic and scapular patterns in reclining positions in bed. Stretching: B/L hamstrings, calves, invertors groups of muscles. Frenkel's exercises: Fowler's position for ataxia in UL and LL movements in PNF diagonal patterns using auditory and visual cues starting involving single joint (assistance was provided if needed). Eyes open, active eye and head movements between two stationary targets as self-selected speed.
Week 2 Promote upper limb muscle strength and coordination Improve postural control in sitting Improve upper and lower limb coordination To improve strength of intrinsic muscles of hand	PNF patterns progressed to active and bilateral patterns in Fowler's position. RS and SR with minimal manual resistance in quadruped and bridge positions. Frenkel's exercises in EOB position with minimal support (emphasizing on multiple/combination joint movements in functional patterns). Exercises to improve strength of intrinsic muscles of hand were incorporated
Week 3 Promote dynamic sitting control and anticipatory postural reactions To initiate and train sit to stand transition To impart lower limb weight bearing and proprioception in standing	Sitting EOB: Starting with midline and then multidirectional reach outs under supervision. RS and SR with manual resistance in sitting EOB. EOB: small amplitude perturbations in all four directions. Incorporated as per the biomechanical principles and facilitatory techniques of NDT. Supported standing holding onto a walker for 5 min, keys points of control at bilateral hips and knees.
Week 4 Promote muscle strength To improve limb coordination Initiate gait training with facilitation	Progression with 1/2 kg weight cuffs for UL/LL muscles in mass functional patterns. Frenkel's exercises with dynamic reversals for limbs to further enhance strength and coordination. Functional lower limb patterns required for gait in parallel bars with therapists support and cues.

\*UL- upper limb, LL- lower limb, EOB- edge of bed, RS- rhythmic stabilization, SR- stabilizing reversals, NDT- neurodevelopmental technique

**Home Based Exercise Regimen [8]:**

The dosage regimen in home based exercise group was similar as that of structured physiotherapeutic program with each

therapy session lasting for 60 minutes. The detailed description of exercise intervention in this program has been included in Table 2.

**Table 2: Overview of Home based exercise regimen.**

Exercise category	Description
Week 1 Seated, stable	Trunk unsupported <ul style="list-style-type: none"> <li>• Side to side weight transfer</li> <li>• Trunk bending</li> <li>• Arm reaches</li> <li>• Foot circles</li> <li>• Toe touches</li> </ul>
Week 2 Seated, dynamic surface	Hands free trunk rotation <ul style="list-style-type: none"> <li>• Foot circles</li> </ul>
Week 3 Standing, stable surface	<ul style="list-style-type: none"> <li>• Feet apart progressing to feet together</li> <li>• Weight shift</li> <li>• Arm raises</li> <li>• Trunk rotations</li> <li>• Up on toes</li> <li>• Up on heels</li> <li>• Eyes closed</li> </ul>
Week 4 Stepping and stooping	Lunges <ul style="list-style-type: none"> <li>• Tandem stepping</li> <li>• Step onto 8 inch step</li> <li>• Floor touches</li> <li>• Arm and contralateral leg lift</li> </ul>



**Figure 2: The patient performing stepping in structured physiotherapeutic program**



**Figure 2: The patient performing forward reach in home based exercise regimen.**

**STATISTICAL ANALYSIS**

Data analysis was done by SPSS software. Baseline characteristics were compared between groups using independent t- test. For all the outcome measures, Student’s t test was used to assess the interventions effects within the groups. Alpha was set at 0.05, and the 95% confidence interval (CI) was calculated. If the significant difference was detected, then independent t test was conducted.

**RESULT**

The mean age (years) of patients included in this study in group A was 45.38±13.8 and in

group B was 45.84±9.3. The demographic profile of the patients namely age, height, weight and BMI as well as baseline scores of MMSE, SARA, BBS, M-FIM, FIST and Gait velocity were matched and found to be having statistically non-significant difference.

Table 3 describes the comparison of mean value for SARA, BBS, FIST, M-FIM and Gait velocity scores before and after intervention within the two groups. The analysis of the scores of SARA and FIST using Student’s t-test indicated significant difference (p<0.05) at week 0 that is baseline and week 4 that is post intervention

in both the groups. The other parameters assessed in the study were balance, functional independence and walking speed using BBS, M-FIM and Gait velocity respectively. The comparison of mean scores of BBS, m-FIM and gait velocity at two different intervals (0 week and 4 week) showed statistically significant difference in group A only ( $p < 0.05$ ).

Further, the analysis regarding improvement of mean scores of SARA revealed in both

the groups have been described in Table 4. The comparison of scores of improvement in SARA indicated statistically non significant difference ( $p > 0.05$ ) between group A and B. Whereas, comparison of improvement of mean value for FIST scores before and after intervention, between Group A and Group B showed statistical significant difference with  $p < 0.05$ .

Table 3: Comparison of mean value for SARA, BBS, FIST, M-FIM and Gait velocity scores at week 0 vs. week 4 within Group A and B

Parameters	Group A				Group B			
	0 week	04 week	t value	P value	0 week	04 week	t value	P value
SARA	13.00±4.5	10.615±3.9	3.054	0.010(S)	13.230±5.9	11.653±4.5	2.555	0.025(S)
BBS	41.08±9.0	47.08±6.1	-5.029	0.024(S)	46.69±6.0	48.46±6.1	-1.852	0.088(NS)
FIST	48.92±4.3	50.92±3.5	-4.052	0.0016(S)	43.23±6.1	46.77±5.0	-2.399	0.0335(S)
M-FIM	70.85±17.1	74.54±18.6	-2.375	0.035(S)	71.23±15.2	74.85±12.9	-2.093	0.058(NS)
Gait velocity	1.16±0.3	1.35±0.23	-3.191	0.007(S)	1.15±0.4	1.17±0.39	-0.413	0.686(NS)

Table 4: Comparison of improvement of mean values for SARA and FIST scores at 0 vs. 4 weeks interval between Group A and Group B

Parameters at 0 vs. 4 weeks	Group A (Mean±SD)	Group B (Mean±SD)	t value	P value
SARA	-2.385±2.8	-1.577±2.2	-0.812	0.576(NS)
FIST	2.00±1.8	4.69±4.2	-2.149	0.015(S)

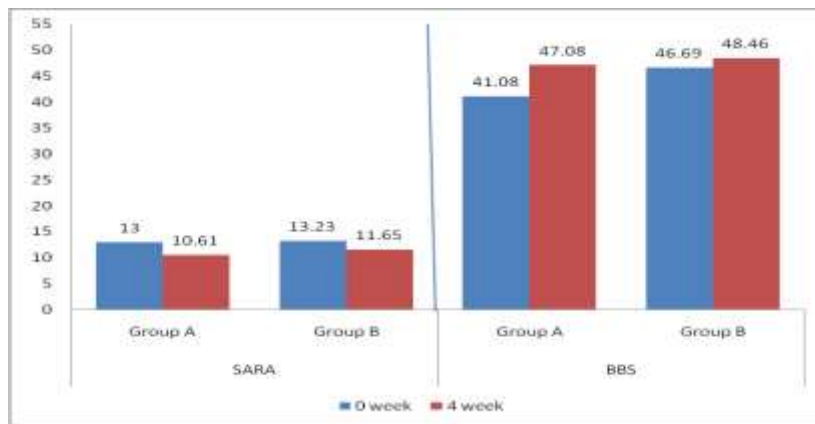


Figure 4: Graphical display of Comparison of Mean values for SARA, BBS, at week 0 and week 4 within group A and B

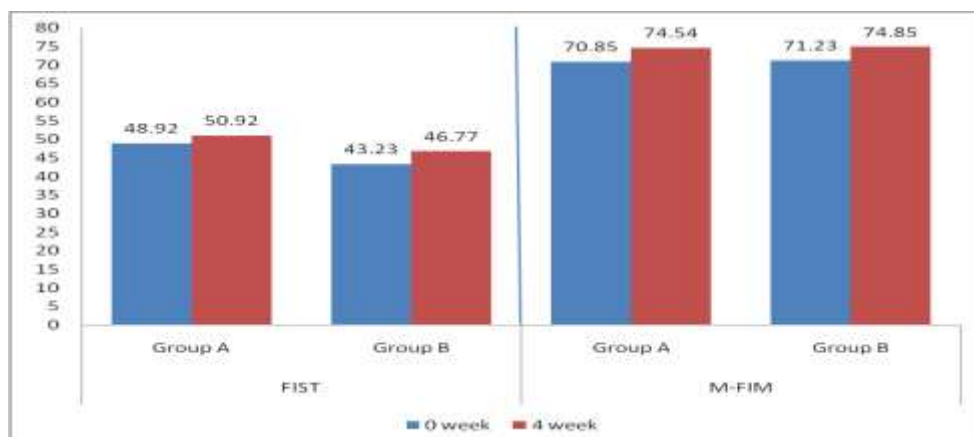


Figure 5: Graphical display of Comparison of Mean values for FIST, M-FIM at week 0 and week 4 within group A and B

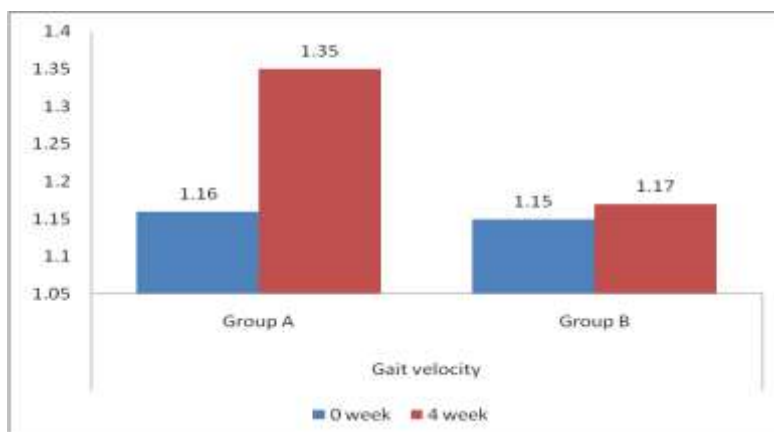


Figure 6: Graphical display of Comparison of Mean values for Gait velocity at week 0 and week 4 within group A and B

## DISCUSSION

The present investigation has been done in Indian rural population for unveiling the effectiveness of physiotherapeutic intervention in cerebellar ataxic patients. These interventions encompass supervised therapies that can be autonomously carried out by patients in the comfort of their own homes. The major impairments in patients affected with cerebellar ataxia are impaired balance and limited mobility that greatly affect their rehabilitation outcomes. The results of current study suggested that structured physiotherapeutic program and home based exercise regimen, both improved severity of ataxia in these patients. The four weeks of structured physiotherapeutic program improved balance, functional independence, sitting abilities and gait velocity. Whereas, home based exercise regimen of the same duration reduced the severity and improved the functional sitting abilities.

The severity of ataxia can vary, affecting voluntary muscle coordination and leading to unsteady movements. This can impact precise movements required for tasks like reaching, grasping, and fine motor activities. Both the groups documented improvement in the scores of SARA, thereby indicating decrease in severity of ataxia. In structured physiotherapeutic program, Frenkel's exercises, namely perception, precision, practice, peak performance and progression and diagonal PNF patterns were incorporated during the intervention to achieve functional movement synergies.<sup>[7]</sup>

The home based exercise regimen was focused on balancing exercises such as side to side weight transfer, foot circles, forward reach, toe touches.<sup>[8]</sup> For structured physiotherapeutic program, as far as severity of ataxia is concerned, the results of previous studies are in concordance with the findings of the present study as suggested by Pallavi et al. (2018)<sup>[9]</sup> and Miyai et al.(2019).<sup>[10]</sup> Keller JL et. al. (2004) and Kim JJ et. al. (2020) also documented improvement in severity of ataxia and thus advocated the application of home based exercise program in these patients.<sup>[8,11]</sup> Further, the findings of the present study revealed that both structured physiotherapeutic program as well as home based exercise regimen, are equally effective in diminishing the affection of ataxia in these patients. This fact can be of tremendous value and can play a great clinically significant role in developing nations like India, especially if the affected population belongs to rural areas. The search of various databases, especially in context to developing nations, clearly suggested the scarcity of published literature on his aspect. Thus the fact that patients belonging to underserved rural areas could benefit from home based exercise program, where there is limited access of skilled professionals and specialist rehabilitation workers, could be of highly tremendous importance for already dependent patients affected with this disorder.

The patients with cerebellar ataxia have difficulties in balance and coordination,

leading to an inability to maintain an upright posture, a tendency to sway or stumble, and challenges in adjusting balance during activities. Sartor Glittenberg, C., et al. has also highlighted that major determinant factor of impaired mobility is impaired balance and coordination in these patients.<sup>[12]</sup> The inferences of the present investigation has showed the improvement in balance in only structured physiotherapeutic program, as evidenced in the improvement in the mean scores of BBS from 41.08 to 47.08. This result was supported by the study conducted by Fatimah Ahmedy et al. (2020) in which they also documented the improvement in the scores of BBS, TUG, SARA, NRS and MBI.<sup>[13]</sup> Conversely, as far as balance and home based exercise regimen is concerned, the results of the current study is not in accordance with the study done by Amy Bastian et al. (2010).<sup>[8]</sup> The possible explanation could be the fact that the effect of only single intervention, that is home balance program, was investigated where the patients serve as their own control. Independence in daily activities in patients with cerebellar ataxia is significantly affected, with coordination-dependent tasks such as dressing, eating, and writing becoming challenging. Cerebellar ataxia can also cause tremors and involuntary movements, which can disrupt the ability to sit still and maintain a stable posture. These movements can lead to uncontrolled swaying, shaking, or jerking while sitting. In this study, functional sitting abilities and functional independence measure were assessed using FIST and M-FIM respectively. The structured physiotherapeutic program revealed improvement in the scores of m-FIM from 70.85 to 74.54 in the duration of four weeks however home based exercise regimen could not reveal improvement in this parameter. These findings suggests that structured physiotherapeutic program improve the functional independence in the activities of daily living in Indian rural population which is of important aspect,

especially of working rural population. As far as, functional sitting abilities is concerned, although both the interventions documented improvement in the scores of FIST. This finding is in accordance with Perlmutter and Gregory et al. (2003).<sup>[14]</sup> Further comparison of improvement highlighted that home based exercise regimen is more effective in improving this outcome measure in comparison to structured physiotherapeutic program as improvement was observed in the scores of FIST only with the patients receiving home based exercise regimen. Considering that FIST is not a commonly employed tool in regular practice, the findings clearly demonstrate a real shift from the anticipated standard outcomes. Consequently, this raises doubts about the appropriateness of utilizing FIST, especially considering its limited utilization by researchers in assessing functional sitting abilities in patients with cerebellar ataxia. Thus, exploring the practical application and validity of FIST, particularly in relation to rural areas, can be a valuable aspect for future investigations in this field.

Additionally, cerebellar ataxia can alter gait, causing an unsteady, irregular, or wide-based walking pattern, resulting in reduced gait velocity. This affects mobility and the ability to walk longer distances. Gait training is an integral component in majority of rehabilitation programs of these patients. The present study has shown the improvement in the walking speed in patients receiving structured physiotherapeutic program only. Miayi et al. also in their study demonstrated promising results, including a reduction in ataxia severity and improved gait speed.<sup>[9]</sup> This suggests that motor learning abilities may be partially preserved in these patients, and functional gains correlate with their capacity for motor learning.<sup>[15]</sup>

In contrast, the findings of the current study did not align with the research conducted by Nardone et al. which examined ambulant participants with degenerative ataxia of different causes.<sup>[16]</sup> The interventions in



their study, conducted by a physical therapist, targeted static and dynamic balance, gait training, and flexibility and strengthening exercises. The improvements were observed in balance and cadence during gait, but there were no significant changes in gait velocity. The shorter duration of the intervention may have contributed to this result. Overall, the present study supports the efficacy of the structured physiotherapeutic program over the home-based exercise regimen in improving gait velocity in rural populations with cerebellar ataxia.

Undoubtedly, this study offers valuable insights into the management of cerebellar ataxia and provides evidence-based guidance for clinical practice. The population investigated in the present context had a wide age range, from 18-65 years. Secondly, it was not possible to conduct a long term follow up as the patients belonged to rural areas and long term compliance was not possible. The wide variation in the age range is attributed to low occurrence rate of this disorder in general. But, in a field where research has been sparse, this study provides profound insights that can shape the development of rehabilitation protocols and drive progress in this realm.

In conclusion, it can be stated that structured physiotherapeutic program and home based exercise regimen, both were effective, in decreasing the severity of ataxia and improving functional sitting abilities in patients with cerebellar ataxia. But home based exercise regimen was more efficacious in improving functional sitting abilities. Further, only structured physiotherapeutic program was only effective in improving motor recovery in patients with cerebellar ataxia belonging to rural areas.

The findings demonstrated the effectiveness of the structured physiotherapeutic program as well as home based exercise program that can assist healthcare professionals in tailoring interventions to address the needs and enhance functional outcomes in these

patients, especially belonging to rural population. It is important for future research to further explore the long-term benefits and sustainability of such programs, as well as their impact on other domains of physical and functional performance. By implementing the findings of this study, healthcare providers can improve the quality of care for patients with cerebellar ataxia and optimize their rehabilitation journey.

#### **Declaration by Authors**

**Ethical Approval:** Approved

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**Conflict of Interest:** The authors declare no conflict of interest.

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