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Original Research Article

Effect of Sensorimotor Training Program on Balance and Gait in Patients with Haemophilia

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ABSTRACT

Background: Haemophilia is a hereditary bleeding disorder that leads to recurrent joint bleeding (hemarthrosis), resulting in joint degeneration, muscle weakness, and proprioceptive impairments. These musculoskeletal deficits contribute to balance disturbances and abnormal gait patterns, increasing the risk of falls and mobility limitations in individuals with haemophilia. Despite advancements in medical management, rehabilitation strategies targeting neuromuscular and proprioceptive deficits remain underexplored.

Aims and Objectives: This study aimed to assess the effect of a sensorimotor training program on balance and gait in individuals with haemophilia. The specific objectives were to evaluate improvements in balance and gait parameters following a structured sensory-motor intervention.

Methodology: A total of 44 participants with haemophilia were recruited for an interventional study using a convenience sampling method. The study involved a four week sensorimotor training program consisting of flexibility exercises, balance training (sensory and motor components), core strengthening, and gait training. Outcome measures included the Single-Leg Stand Test (SLS), Timed Up and Go (TUG) test, and 2-Minute Walk Test (2MWT). Data were analysed using paired t-tests, with statistical significance set at $p < 0.05$.

Results: Significant improvements were observed post-intervention in all outcome measures. Single-leg stance times increased (Right leg: 15.30 ± 7.28 to 21.59 ± 9.13 sec, Left leg: 13.93 ± 6.04 to 21.07 ± 7.59 sec, $p < 0.001$). TUG test times decreased (25.35 ± 7.80 to 19.55 ± 6.69 sec, $p < 0.001$), indicating enhanced agility and dynamic balance. The 2MWT distances increased (140.11 ± 34.03 to 158.19 ± 34.99 meters, $p < 0.001$), reflecting improved walking endurance.

Conclusion: The sensorimotor training program produced statistically and clinically significant improvements in balance and gait in individuals with haemophilia. Enhanced proprioception, neuromuscular coordination, and postural control contributed to increased stability and functional mobility. These findings highlight the importance of incorporating sensorimotor training into standard physiotherapy care for haemophilia management.

Keywords: Haemophilia, Sensorimotor Training, Balance, Gait, Postural Stability, Proprioception, Functional Mobility, Fall Risk.

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BACKGROUND

Haemophilia is a genetic bleeding disorder caused by missing clotting factors (factor VIII or IX) [1]. People with haemophilia bleed excessively, often into joints (hemarthroses) and soft tissues [2]. Repeated bleeding into the same joint leads to chronic inflammation and arthritis (haemophilic arthropathy) [3]. Over time, this joint damage causes pain, stiffness, and reduced range of motion in affected limbs[2,3]. Patients with haemophilia may also develop osteoporosis due to long periods of immobility [2,3] These effects mean affected individuals often move less and walk more carefully, which can further weaken muscles and bones.

Risk of Falls, Balance, and Gait Issues in Haemophilia: Falls are common in older adults and usually result from a combination of personal and environmental risk factors [4] Intrinsic factors include poor balance, muscle weakness, joint pain, fear of falling, and diminished proprioception, while extrinsic factors may involve environmental hazards such as loose rugs or poor lighting [4]. Individuals with haemophilia often share these general risk factors, but also face condition-specific challenges due to haemophilic arthropathy—a chronic joint disease resulting from recurrent hemarthroses.

In haemophilia, the repeated bleeding into joints—most commonly the knees, ankles, and elbows—triggers a cascade of pathological changes. The presence of blood in the joint cavity leads to iron deposition from hemoglobin breakdown, which induces chronic synovial inflammation and oxidative stress[5]. This results in synovial hypertrophy and proliferation (pannus formation), damaging the articular cartilage and subchondral bone over time. As the joint degrades, mechanoreceptors—sensory receptors embedded in joint capsules, ligaments, and muscles that detect movement and position—are progressively impaired or destroyed. The loss of these proprioceptive signals disrupts the brain's ability to accurately detect limb position and movement, which are essential for maintaining balance and coordinating gait [6].

Additionally, the inflammation and pain associated with joint damage lead to muscle disuse and atrophy. Patients often avoid using affected joints, which exacerbates muscle weakness and reduces neuromuscular control. Over time, this leads to altered movement patterns, joint stiffness, reduced range of motion, and further instability. This chronic dysfunction of the musculoskeletal and sensory systems increases postural sway, reduces the ability to make quick balance corrections, and compromises dynamic stability during walking.

Research supports the presence of significant balance impairments even in individuals with mild to moderate haemophilia. For example, children with haemophilic arthropathy exhibit greater postural instability and more frequent falls compared to their healthy peers [7]. Altered gait patterns—such as slower walking speed, reduced stride length, increased step width, and compensatory movements—are common adaptations developed to avoid pain and maintain stability. However, these adaptations often increase energy expenditure and fatigue, further limiting mobility and functional independence.

Falls are particularly dangerous in people with haemophilia due to the high risk of serious bleeding, including into muscles, joints, and internal tissues. Moreover, haemophilia-related bone loss (osteopenia or osteoporosis), common due to chronic immobility, increases the likelihood of fractures even from minor falls [4,7]. Thus, the interplay of joint pathology, sensory deficits, and muscular deconditioning places individuals with haemophilia at a significantly elevated risk for falls and mobility-related complications.

Sensorimotor Training: Sensorimotor training includes exercises designed to improve balance, coordination, and body awareness. It works by stimulating sensors in muscles and joints (mechanoreceptors) to enhance the brain's sense of limb position and movement [8]. In practice, patients may perform tasks such as standing on wobble boards, moving with their eyes closed, or coordinating arm and leg movements under controlled conditions. Studies in haemophilia suggest benefits from such training. For example, combining balance exercises with muscle strengthening reduced body sway and improved stability in patients with haemophilic joint damage [9]. Proprioceptive training has also been shown to improve gait efficiency by reducing uneven steps and compensatory movements [10], and functional exercises can increase walking speed, step length, and symmetry [11]. Overall, sensorimotor programs help patients move more steadily and confidently.

Current physiotherapy for haemophilia tends to emphasize pain relief, strength, and flexibility, but often overlooks balance and sensory-motor control [12]. This leaves a gap in care, as deficits in balance and proprioception may persist even after standard therapy. Sensorimotor exercises have been used successfully in other musculoskeletal conditions but have not been well studied in people with haemophilia. To address this gap, our study evaluates whether a 4-week sensorimotor training program can improve balance and walking ability in patients with haemophilia. We aim to demonstrate that this training can enhance functional mobility, reduce fall risk, and increase confidence in movement [13].

This article reports that a structured four-week sensorimotor training program significantly improved balance and gait measures in patients with haemophilia.

METHODOLOGY

Study Design: Quasi Experimental Study (Pre test – Post test Design)

Study Site: Nanavati Max Superspeciality Hospital

Sampling Method: Convenience sampling

Duration of Study: 1 year

Duration of Data Collection: 6 months

Sample Size: 44

Study Population: Patients with Haemophilia.

Inclusion criteria:

1. Independent ambulatory patients with Haemophilia A and Haemophilia B.

2. Patients showing affection on the Haemophilia Joint Health Score

Exclusion Criteria:

1. Non-ambulatory patients with Haemophilia.

2. With other musculoskeletal and neurological disorders, people who have Intellectual Disabilities.

OUTCOME MEASURES

Table 1: Outcome Measure.

Outcome Measure	Objective	Timeline
One leg stand	To assess **static balance** and **postural stability** by measuring the ability to maintain a single-leg stance without support.	Baseline & Post Intervention
Time up and go test	To evaluate **functional mobility**, **dynamic balance**, and **fall risk** during a simple transitional movement sequence	Baseline & Post Intervention
2-minute walk test	To measure **aerobic capacity** and **walking endurance** by recording the maximum distance a person can walk in 2 minutes at a self-paced speed.	

Procedure: CTRI registration was done, and Nanavati Max Hospital provided ethical approval. This was followed by patient selection and screening for the trial. Informed Consent was obtained after patient education. Baseline assessment and demographic data collection were completed. There were twelve sessions of the assigned intervention. An assessment followed a four-week intervention.

PROTOCOL (4 weeks): All exercise sessions were conducted under the direct supervision of a qualified physiotherapist to ensure safety and correct execution. Precautionary measures included 1-minute rest between sets and 1–3 minutes between exercises, with adequate external support (e.g., handrails or therapist assistance) provided as needed.

Balance Protocol

	WEEK 1	WEEK 2	WEEK	WEEK 4
Flexibility	Ankle toe movements and rotations and calf stretches	Ankle toe movements and rotations and calf stretches	Ankle toe movements and rotations and calf stretches	Ankle toe movements and rotations and calf stretches
Sensory training	Wall slides: 20 reps* 1 set	Wall slides: 20 reps*2 sets	Wall slides with medicine ball: 20 reps* 1 set	Wall slides with medicine ball: 20 reps* 2 set
Balance training (sensory component)	Bipedal wobble (Eyes Open) board exercise (bidirectional wobble board) 3mins	Bipedal wobble board exercise (Eyes open) (bidirectional wobble board) 3mins × 2 sets	Bipedal wobble (Eyes Closed) board exercise (bidirectional wobble board) 3mins	Bipedal wobble board exercise (Eyes closed) (bidirectional wobble board) 3mins × 2 sets
	Unipedal stance (green oval stability trainer) First 3 session: 3mins	Unipedal stance (blue oval stability trainer) 3mins	Unipedal stance (black stability trainer) 3mins	Unipedal stance (purple round stability trainer) 3mins
	Tandem Stance (green oval stability trainer) Eyes Open 3 min	Tandem Stance (blue oval stability trainer) Eyes Open 3mins	Tandem Stance (green oval stability trainer) Eyes Closed 3mins	Tandem Stance (blue oval stability trainer) Eyes Closed 3mins

Exercises were adapted based on joint health, pain, or fatigue levels to prevent hemarthrosis. Participants were instructed to report any discomfort or signs of bleeding immediately, and exercises involving compromised joints were modified or replaced. These safeguards ensured therapeutic benefit while minimizing risk.

	WEEK 1	WEEK 2	WEEK	WEEK 4
Balance training (motor component)	Toe and Heel raise (green oval stability trainer) 10 reps	Toe and Heel raise (green oval stability trainer) 10 reps × 2 sets	Toe and Heel raise (blue oval stability trainer) 10 reps	Toe and Heel raise (blue oval stability trainer) 10 reps × 2 sets
	Sit to stance (green oval stability trainer) 5 reps	Sit to stance (green oval stability trainer) 5 reps x 2 sets	Sit to stance (blue oval stability trainer) 5 reps	Sit to stance (blue oval stability trainer) 5 reps x 2 sets
Core strengthening	Back bridging with 5 second hold 10 reps	Back bridging with bosu ball 5 second hold 10 reps	Back bridging with bosu ball 5 second hold 10 reps x 2sets	Back bridging on gym ball 5 sec hold First 3 sessions: 10 reps
Gait training	Normal walk: 3 mins	High march walk: 3mins	Backward walk: 3mins	High march backward walk 3 mins
	Walk on the line: 3 reps	Tandem walk: 3reps	High march tandem walk 3reps	High march tandem backward walk 3 reps
1 minute of rest between the sets; 1 minute to 3 minutes of rest between the two exercises. Adequate support will be provided wherever needed				

Table 2: Balance Protocol.

SENSORY TRAINING	WEEK 1	WEEK 2	WEEK 3	WEEK 4
	Mat walking on foam surface	Mat walking on 2 cm thick foam	Side walking on 2 cm thick mat	Retro walking on 10 cm thick foam
	Bipedal stance on wood box with cotton	Bipedal stance on wood box with cotton (feet together)	Bipedal stance on wood box with cotton (feet together and eyes closed)	Bipedal stance on wood box with cotton (feet together and eyes closed with perturbations)
	Sandpaper was placed on the ground and volunteers had to alternatively slide their feet on it	Spot marching on sandpaper	One leg stance on sand paper	Single leg stance on sand paper throw and catch a ball

RESULTS AND DISCUSSION

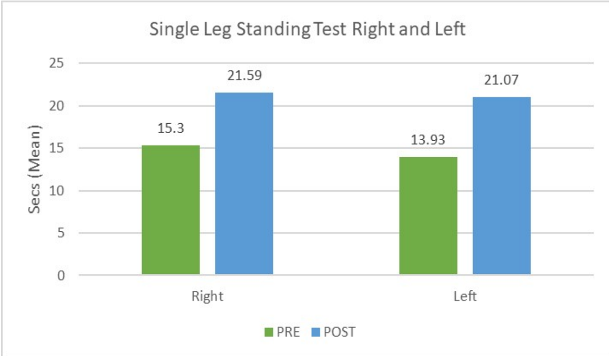
The data analysis was conducted using SPSS version 29. To assess the normality of the data, the Shapiro-Wilk test was applied to the outcome measures both pre and post-intervention. Since the p-values obtained were greater than 0.05, it was concluded that the data followed a normal distribution. As a result, parametric tests were appropriate for further analysis.

For intra-group comparisons, paired t-tests were used to assess within-group differences, In all analyses, results were considered statistically significant if the p-value was less than or equal to 0.05.

Population Characteristics: 44 participants were recruited for the study. The mean age of the participants was 32.68 ± 8.26.

Table 3: Data Analysis of Intra Group with mean, standard deviation and p-value.

Outcome Measures	Pre	Post
Single Leg Standing Test (Rt) Secs (mean)	15.30 ±7.28	21.59 ± 9.13
Single Leg Standing Test (Lt) Secs (mean)	13.93 ±6.04	21.07 ±7.59
Timed Up and Go Test Secs (mean)	25.35 ±7.80	19.55 ± 6.69
2 Minute Walk Test Meters (mean)	140.11 ± 34.033	158.19. ± 34.99.97



Graph 1: Single-leg stand test for left and right legs.

Table 4: Single leg stand test for left and right leg.

ONE LEG STAND TEST	PRE	POST	p VALUE
Right	15.30 ±7.28	21.59±9.13	p<0.001
Left	**13.93±6.04**	**21.07±7.59**	**p<0.001**

There is a significant change observed both clinically and statistically, in intra group values of one leg stand test (right and left) . The p value obtained post paired t test was $p<0.001$ (i.e. $p<0.05$)

Graph 2: Timed up and go test.

Table 5: Timed Up and Go

Timed Up and Go	PRE	POST	p VALUE
	25.35±7.80	19.55±6.69	p<0.001

There is a significant change observed both clinically and statistically, in intra group values of Timed Up And Go Test . The p value obtained post paired t test was $p<0.001$ (i.e. $p<0.05$)

Fig. 1: Ankle Movements

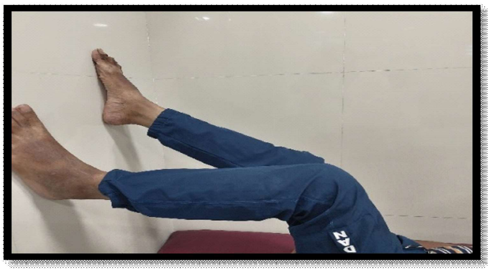


Fig. 2: Wall Slides

Fig. 3: Wobble Board exercises

Fig. 4: Unipedal Stance Stability Trainer

Fig. 5: Tandem Stance Stability Trainer

Fig. 6: Heel Raise Stability Trainer

Fig. 7: Sit to Stand

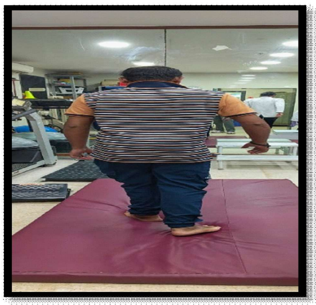
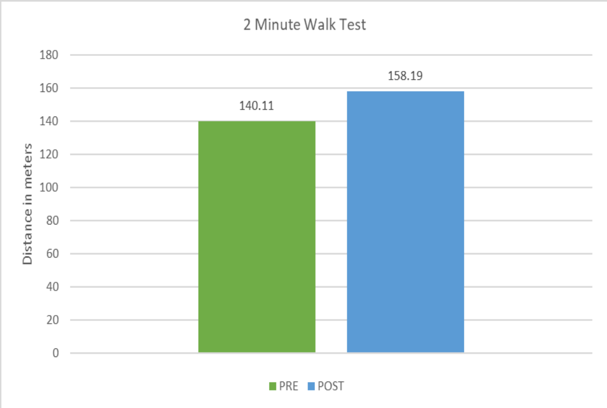


Fig. 8: Walking on Mat

Fig. 9: Walking in straignt Line



Graph 3: 2 Minute Walk Test.

Table 6: 2 Minute Walk Test.

2 Minute Walk Test	PRE	POST	p VALUE
	140.11 ± 34.33	158.19 ± 34.99	p<0.001

There is a significant change observed both clinically and statistically, in intra group values of 2 Minute Walk Test. The p value obtained post paired t test was p<0.001 (i.e. p<0.05).

DISCUSSION

The present study demonstrated significant improvements in balance and gait among individuals with haemophilia following a four-week sensorimotor training program. These findings can be attributed to specific physiological adaptations that occur when the neuromuscular system is exposed to controlled, repetitive sensory-motor challenges. In patients with haemophilia, chronic joint bleeding leads to the degradation of articular cartilage, synovial inflammation, and eventual destruction of mechanoreceptors—structures critical for proprioception and postural control [5, 12]. Sensorimotor training helps re-engage these compromised systems by stimulating joint and muscle receptors through carefully graded activities. Such exercises enhance joint position sense, reactive balance, and muscular coordination, thereby improving the body's ability to respond to perturbations [9,12]. These neuromuscular improvements likely underlie the observed gains in the one-leg stand and Timed Up and Go (TUG) test scores, both of which reflect static and dynamic postural stability.

Balance and gait are inherently multisensory functions that depend on the integration of somatosensory, vestibular, and visual information. In haemophilia, the somatosensory domain—particularly proprioceptive input from affected joints—is often compromised. As described in previous studies [6,13], the loss of mechanoreceptive feedback reduces the central nervous system's capacity to interpret limb position and movement, increasing reliance on visual and vestibular systems. Sensorimotor training appears to restore this sensory balance by encouraging the central nervous system to recalibrate and integrate inputs more efficiently. In our study, the improvements in TUG scores indicate better transitional movement control, suggesting that participants became more capable of initiating and completing dynamic tasks with greater confidence and less compensatory effort.

Improved performance in the 12-Minute Walk Test (12MWT) further illustrates gains in sustained walking ability and energy efficiency. Individuals with haemophilia often develop maladaptive gait patterns—such as shortened stride length and widened base of support—to reduce joint pain and instability. While protective in the short term, these compensations are metabolically inefficient and contribute to early fatigue. Sensorimotor training enhances core stability and lower limb control, which can restore more symmetrical and biomechanically efficient gait. By reducing dependence on visual cues and promoting automatic postural strategies, patients may expend less energy during ambulation and feel more secure in their movements [5]. This could explain the increased walking distances observed post-intervention.

When compared to previous research, our results align well with studies demonstrating the effectiveness of proprioceptive and balance-focused rehabilitation in haemophilia and related musculoskeletal conditions. Studies have reported improved joint stability and reduced sway following a six-week proprioceptive training program in adults with haemophilic arthropathy. [9,10] It has also been highlighted that interventions targeting sensorimotor function have led to measurable improvements in gait speed, symmetry, and postural transitions [10-13]. Notably, our study achieved significant outcomes with a relatively shorter, four-week intervention, suggesting that the intensity and specificity of training may be more critical than duration alone. This highlights the efficiency and practicality of incorporating sensorimotor approaches into routine physiotherapy for individuals with haemophilia.

The clinical implications of these findings are substantial. Traditional rehabilitation for haemophilia often emphasizes joint protection, strengthening, and pain management but may insufficiently address proprioceptive deficits and balance impairments that contribute to fall risk. Our results reinforce the need to integrate sensorimotor training as a core element of haemophilia rehabilitation, especially for individuals with moderate arthropathy or a history of instability. The structured nature of the intervention—supervised by a physiotherapist, with tailored rest periods and support—ensured both efficacy and safety. This approach also encourages patient adherence and builds movement confidence. Beyond physical gains, improvements in balance and gait may promote psychosocial benefits, including increased independence and participation, which are integral to quality of life in chronic conditions.

Limitations: Despite its promising results, the study had some limitations. The sample size was relatively small, which may limit the generalizability of the findings to the broader haemophilia population. Additionally, the absence of a control group prevents conclusive attribution of observed improvements solely to the intervention. The short intervention duration (four weeks) and the lack of long-term follow-up data limit insight into the sustainability of the gains. Variability in joint involvement among participants was not controlled for, which may have influenced functional outcomes. Future studies with larger, randomized controlled samples and long-term follow-up are needed to validate and extend these findings.

CONCLUSION

The findings of this study provide evidence that a structured four-week sensorimotor training program significantly improves balance, gait, and functional mobility in individuals with haemophilia. Statistically significant gains observed in the One-Leg Stand, Timed Up and Go test, and 12-Minute Walk Test indicate enhanced proprioception, postural control, and walking endurance. These improvements reflect the effectiveness of targeting neuromuscular and sensory deficits through tailored interventions. The study supports the integration of sensorimotor training into routine physiotherapy for individuals with haemophilia to reduce fall risk, enhance mobility, and promote functional independence.

Authors contribution

Eric Merces Sousa: Selection of research topic, research process and design, data collection, manuscript drafting, editing, and writing.

Sabah Thaver: Selection of research topic, research process and design, data collection, manuscript drafting, editing, and writing.

Ali Irani: Supervision, contribution to discussion, and final manuscript editing.

Conflicts of interest: None

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