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Aquatic versus Land-Based Balance Training for Fall Risk in Diabetic Peripheral Neuropathy: A Single-Blind Randomized Controlled Trial

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ABSTRACT

Background: Diabetic peripheral neuropathy (DPN) is a common complication of diabetes that leads to sensory loss, impaired proprioception, muscle weakness, and balance deficits, increasing the risk of falls and functional limitations. Exercise-based rehabilitation is effective in improving balance; however, it remains unclear whether aquatic-based training offers additional benefits compared to conventional training.

Materials and Methods: A two-armed, parallel group, open labelled, randomized controlled trial was conducted involving 56 participants (n=56) aged 40–75 years, having DPN. Participants were randomly allocated into two groups: land group (n=28) and aquatic group (n=28) using the Sequentially Numbered Opaque Sealed Envelope (SNOSE) method. Both groups received 45-minute sessions, 3 sessions/ week, for 4 weeks (total: 12 sessions) based on the Fitness and Mobility Exercise (FAME) protocol. Balance and functional mobility were assessed using the BBS and TUG scores at baseline, post-intervention, and one-month follow-up.

Results: Both groups demonstrated significant improvements over time in BBS and TUG scores ($p<0.05$), which were maintained at one-month follow-up. However, no significant between-group differences were observed ($p>0.05$).

Discussion: Both interventions produced meaningful improvements in balance and functional mobility; however, no clear superiority of aquatic training was observed. Structured balance training is effective in improving postural stability and functional mobility in individuals with DPN.

Conclusion: Both training programs effectively improve balance and reduce fall risk in adults with DPN. Aquatic therapy may serve as a practical alternative for individuals who benefit from reduced weight-bearing and greater confidence during exercise.

Keywords: Diabetic peripheral neuropathy, aquatic exercise, fall risk, balance rehabilitation.

INTRODUCTION

Diabetic peripheral neuropathy (DPN) is a frequently encountered long-term complication of diabetes mellitus that affects sensory and motor function. Individuals with DPN commonly present with diminished sensation, impaired proprioceptive feedback, distal muscle weakness, and deficits in postural regulation.[1,7,18]As the condition progresses, these impairments can interfere with normal gait mechanics, compromise balance, and increase susceptibility to falls, ultimately affecting independence and overall quality of life.[2,3,18]Although pharmacological and medical management of diabetes have advanced considerably, mobility-related limitations continue to pose a major challenge for many individuals living with DPN.[3,19]

Rehabilitation interventions based on exercise have become a cornerstone in the management of these functional deficits.[13]Previous investigations have shown that programmes incorporating balance retraining, strengthening exercises, gait practice, and sensorimotor

activities can improve stability, mobility, and fall-related outcomes among people with DPN.[8,10,12,14]Consequently, structured exercise is now widely recognized as an essential component of comprehensive rehabilitation for this population.[13,20]

Aquatic therapy has gained increasing attention as a rehabilitation modality that may address several limitations associated with conventional land-based exercise. The physical properties of water such as buoyancy, hydrostatic pressure, viscosity, and thermal effects which create a unique therapeutic environment that reduces joint loading, enhances postural support, and allows safer movement execution.[9]These properties are particularly relevant for individuals with diabetic peripheral neuropathy, who often experience fear of falling, sensory deficits, and movement insecurity. [4,9]Evidence from older adult populations as well as neurological and musculoskeletal conditions suggests that aquatic exercise can positively influence balance and mobility performance.[15,21,22,23]Thus, the dynamic properties of water and the recent studies done on various musculoskeletal and neurological conditions suggest that aquatic therapy provides a potent therapeutic environment that can enhance exercise participation, reduce symptom burden, and promote functional recovery across diverse clinical populations.[24,25,26]

While conventional land-based balance training improves lower-limb strength, proprioception, postural control, and gait through task-specific weight-bearing practice, it may be challenging for individuals with diabetic peripheral neuropathy because pain, sensory deficits, impaired balance, and fear of falling can limit exercise performance and adherence. In contrast, aquatic therapy provides a supportive environment through buoyancy and hydrostatic pressure, allowing patients to perform similar functional and balance activities with reduced joint loading, enhanced sensory stimulation, and greater movement confidence, thereby facilitating safe and progressive rehabilitation.[9,15,21,26]

Although aquatic therapy has shown benefits in older adults and neurological conditions, evidence directly comparing aquatic and land-based training in DPN remains limited. Accordingly, the present randomised controlled trial was undertaken to hypothesis that aquatic-based balance training will produce balance and functional mobility outcomes comparable or better outcomes achieved through land-based balance training in adults with diabetic peripheral neuropathy.

OBJECTIVES

The primary objective of this study was to compare the effectiveness of a 4-week aquatic-based balance training programme with a 4-week land-based balance training programme on balance and functional mobility, as measured by the Berg Balance Scale (BBS) and Timed Up and Go (TUG) test, in adults with diabetic peripheral neuropathy.

The secondary objective was to examine the retention of treatment effects by evaluating the maintenance of improvements in balance and functional mobility at the 1-month follow-up.

REVIEW OF LITERATURE

- **Diabetic Peripheral Neuropathy and Fall Risk**

1. **Jimenez-Mazuelas et al. (2024)** conducted a multisite randomized controlled trial involving 44 older adults with diabetic peripheral neuropathy (DPN) to evaluate a Feldenkrais-based sensorimotor exercise program. Participants received either 16 sessions over eight weeks or standard diabetic foot-care education. The intervention significantly improved somatosensory postural control, dynamic balance, Timed Up and Go performance, fear of falling, and several quality-of-life domains. The authors concluded that sensorimotor training is a safe and effective strategy for improving balance and reducing fall risk in older adults with DPN.[27]
2. **Ahmad et al. (2020)** investigated the effects of an eight-week sensorimotor and gait training program in 38 individuals with DPN. Participants receiving supervised training demonstrated significant improvements in proprioception, peroneal nerve conduction velocity, tibial nerve latency, and activation of key postural muscles including the tibialis anterior, gastrocnemius, and multifidus. The findings suggested that sensorimotor and gait training enhances neural function,

muscular coordination, balance, and gait efficiency, thereby reducing fall risk in individuals with DPN.[10]

3. **Streckmann et al. (2014)** conducted a systematic review evaluating exercise interventions in individuals with peripheral neuropathy, including diabetic peripheral neuropathy. The review demonstrated that structured exercise programmes incorporating balance, strength, endurance, and sensorimotor training improved postural stability, gait performance, muscle strength, and functional mobility. The authors concluded that exercise-based rehabilitation is a safe and effective strategy for reducing functional impairments and fall risk in individuals with peripheral neuropathy.[13]

Relevance: These studies collectively establish that DPN impairs postural control and increases fall risk. They support the implementation of structured balance-oriented rehabilitation programmes aimed at improving functional mobility and reducing falls in this population.

- **Exercise-Based Balance Rehabilitation**

4. **Kim et al. (2014)** evaluated an eight-week community-based fall prevention program based on the Fitness and Mobility Exercise (FAME) protocol in older adults. The intervention incorporated balance, strengthening, flexibility, endurance, and functional exercises. Significant improvements were observed in activity participation and balance, along with reduced fall risk. The study highlighted the importance of addressing participation and social engagement, in addition to physical function, when designing fall prevention programs for older adults.[28]

5. **Venkataraman et al. (2019**) conducted a single-blind randomized controlled trial to investigate the effectiveness of a structured strength and balance training programme in individuals with diabetic peripheral neuropathy. The intervention consisted of lower-limb strengthening, balance retraining, range-of-motion exercises, and functional mobility activities delivered over eight weeks. Although no significant improvement was observed in health-related quality of life, participants demonstrated significant gains in functional mobility, ankle muscle strength, knee range of motion, balance confidence, and performance on the Timed Up and Go (TUG) and Five Times Sit-to-Stand (FTSTS) tests. The authors concluded that structured exercise interventions effectively improve functional status and may contribute to reducing fall risk in individuals with diabetic peripheral neuropathy.[8]

6. **Salsabili et al. (2015)** investigated the effects of a task-oriented motor training programme on gait characteristics in individuals with type 2 diabetes and diabetic peripheral neuropathy. The intervention emphasized functional activities including balance exercises, gait training, weight-shifting, stepping tasks, and lower-limb strengthening performed over a structured training period. The study reported significant improvements in gait velocity, cadence, stride length, and walking performance, indicating enhanced motor control and functional mobility following the intervention. The findings highlighted that repetitive task-oriented exercises promote motor learning and improve gait performance in individuals with diabetic peripheral neuropathy.[12]

Relevance: Collectively, these studies support the effectiveness of structured exercise-based rehabilitation in improving balance, gait, and functional mobility in individuals with diabetic peripheral neuropathy. They provide the scientific basis for the use of the FAME protocol in the present study and highlight the need to compare its effectiveness when delivered in land-based and aquatic environments.

- **Evidence Supporting Aquatic Therapy**

7. **Melo et al. (2023)** performed a systematic review and meta-analysis of 11 studies involving 395 community-dwelling older adults to compare aquatic and land-based exercise. Both interventions improved physical function; however, aquatic therapy demonstrated greater improvements in balance, gait performance, functional reach, and fear of falling. The review concluded that aquatic exercise is a safe and effective

intervention for enhancing mobility, confidence, and quality of life in older adults, although further high-quality trials are required.[15]

8. **Nissim et al. (2024)** proposed a randomized controlled trial comparing aquatic and land-based exercise in cancer survivors experiencing fatigue and neuropathy following chemotherapy. Participants will engage in either aquatic Ai Chi, land-based exercise, or no intervention for eight weeks. Outcomes include neuropathy, severity, activity participation, fatigue, quality of life, and return to work. The study underscores the potential role of aquatic therapy as a non-invasive rehabilitation strategy for improving functional outcomes and participation in individuals with neuropathic symptoms.[17]
9. **Muthukrishnan et al. (2024)** examined water-based and land-based perturbation balance training in older adults with chronic low back pain. After six weeks, the aquatic group demonstrated greater improvements in pain, fear-avoidance beliefs, fall efficacy, and flexibility compared with the land-based group. The authors suggested that the supportive and low-impact aquatic environment may facilitate more effective postural training and confidence-building, making it a promising approach for balance rehabilitation and fall prevention.[16]

Relevance: These studies indicate that aquatic environments may provide additional therapeutic advantages for balance retraining, confidence building, and mobility enhancement, thereby supporting the investigation of aquatic-based exercise programmes in populations with balanced impairments.

- **Comparative Studies Between Aquatic and Land-Based Rehabilitation**

10. **Zivi et al. (2018)** compared aquatic physiotherapy with conventional land-based rehabilitation in 40 individuals with peripheral neuropathies. Following a four-week program, both groups demonstrated significant improvements in balance and gait. However, the aquatic therapy group showed greater gains in Dynamic Gait Index scores, indicating superior adaptability during complex walking tasks. The findings suggest that aquatic physiotherapy is at least as effective as land-based rehabilitation and may provide additional benefits for dynamic balance training.[11]

Relevance: Although comparative studies exist, evidence specifically comparing aquatic and land-based balance exercise programmes in individuals with diabetic peripheral neuropathy remains limited. This gap forms the basis for the present randomized controlled trial, which aims to determine whether aquatic-based balance exercises offer additional benefits over conventional land-based training.

MATERIALS AND METHODS

Study Design: Two-armed, parallel group, open labeled, randomized controlled trial was conducted to compare the effectiveness of aquatic-based and land-based balance training in individuals with diabetic peripheral neuropathy (DPN).

Participants and Sampling: A total of 56 community-dwelling individuals diagnosed with diabetic peripheral neuropathy, aged 40–75 years, were recruited and equally allocated to an aqua-based therapy group (n = 28) and a land-based therapy group (n = 28). Sample size was determined using G*Power 3.1.9.7 for a two-tailed independent t-test (difference between two independent means) with an effect size of 0.99, $\alpha = 0.05$, power = 0.95, and an allocation ratio of 1:1, yielding a required sample size of 56 participants (28 per group).

Participants were eligible if they had a diagnosis of type 2 diabetes mellitus for at least one year with clinically confirmed diabetic peripheral neuropathy, diagnosed by a registered physician with a Michigan Neuropathy Screening Instrument (MNSI) questionnaire score ≥4 and/or an MNSI physical examination score ≥2.5. Age between 40 and 75 years, Falls Efficacy Scale-International (FES-I) score ≥26, HbA1c ≤9% within the previous three months, Montreal Cognitive Assessment (MoCA) score ≥26, and the ability to ambulate independently with or without an assistive device.

Participants were excluded if they had severe

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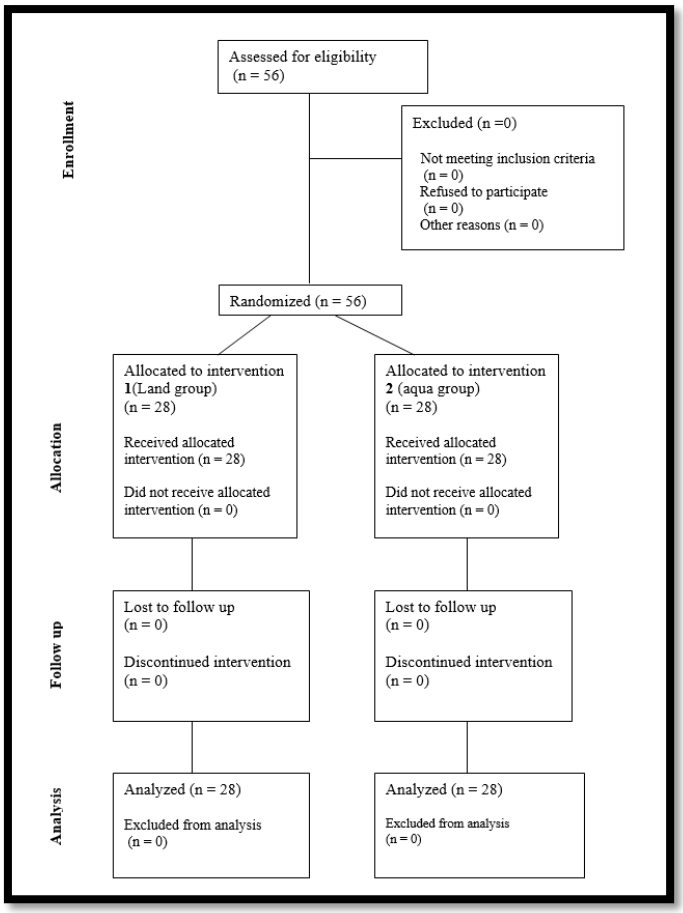
neuropathy; significant cardiovascular, respiratory, orthopedic, neurological, or cognitive impairments that could interfere with study participation; or open wounds, active skin infections, dermatological lesions, or hydrophobia (fear of water).

Randomization and Allocation: Participants were allocated into two groups using the Sequentially Numbered, Opaque, Sealed Envelope (SNOSE) method to ensure both randomization and allocation concealment. Fifty-six envelopes were prepared in equal 1:1 number for the interventional group (aqua) and the conventional group (land). Each envelope was identical in appearance, securely sealed with tamper-proof adhesive, and thoroughly shuffled to avoid prediction of group assignment. An independent data analyst (who was not involved in the intervention or assessment phases) conducted the randomization process through the online application Research Randomizer. This analyst also handled the final data analysis while remaining blinded to group identity, thereby maintaining impartiality and minimizing analytical bias This method ensured proper random allocation and concealment, following the standards set by the CONSORT guidelines.

Figure 01: Sequentially numbered, sealed envelopes



Figure 2: Consort Diagram



Intervention: A standardized exercise intervention based on the Fitness and Mobility Exercise (FAME) protocol was administered to both groups. 5 Intervention fidelity was ensured through the use of a standardized FAME protocol delivered by the same physiotherapist across both groups, with identical exercise frequency, duration, progression, and intensity, differing only in the exercise environment (land or aquatic). Attendance and adherence were excellent, with all 56 participants completing the 4-week intervention and one-month follow-up assessments, resulting in a 100% retention rate. No adverse events or intervention-related complications were reported.
The FAME protocol was selected because of its emphasis on functional strengthening, dynamic balance, agility, and mobility training, all of which are commonly affected in individuals with DPN and old age. 5,6

Each session consisted of four components:

1. **Warm-up (10 minutes):** Gentle joint mobility exercises, marching on the spot, and multidirectional walking activities were performed to prepare participants for exercise and promote lower-limb circulation.
2. **Functional Strengthening:** Exercises included sit-to-stand practice, squats, heel raises, toe raises, and step-ups. These activities targeted lower-limb muscle groups essential for postural stability and gait performance.
3. **Balance and Agility Training:** Participants performed static and dynamic balance tasks, multidirectional stepping, tandem walking, obstacle negotiation, weight-shifting activities, and functional reaching exercises. Difficulty was progressively increased according to individual performance.
4. **Cool-down:** Low-intensity walking and stretching exercises were performed to facilitate recovery and reduce post-exercise fatigue.

Land-Based Training and Precautions: Land-based exercise sessions were conducted in a safe, well-lit environment under continuous physiotherapist supervision. Participants received standardized instructions and demonstrations before each session, while fatigue, exercise tolerance, and safety were monitored throughout. Sessions were discontinued immediately if any pain, discomfort, or adverse symptoms were reported.

Aquatic-Based Training and Precautions: Participants in the aquatic group completed the same exercise program in a temperature-controlled hydrotherapy pool maintained between 31°C and 33°C. Exercises were performed in waist-deep water, allowing partial weight-bearing while utilizing the supportive properties of buoyancy and hydrostatic pressure.
Aquatic exercise sessions were conducted under continuous in-pool supervision by a physiotherapist certified in aquatic therapy. Standardized instructions were provided prior to each session, and participant safety, fatigue levels, and exercise tolerance were closely monitored throughout the intervention. Sessions were terminated immediately if participants experienced pain, discomfort, or adverse symptoms.
Adverse events were continuously monitored throughout the intervention through therapist observation and participant feedback. No intervention-related adverse events or complications were reported during the study period.

Outcome Measures: Outcome measures were assessed at three time points: baseline (pre-intervention), immediately after completion of the four-week intervention (post-intervention), and one month following completion of the program (follow-up).

The primary outcome measures were:

Berg Balance Scale (BBS): A 14-item clinical scale used to evaluate static and dynamic balance performance was used for this study. Scores range from 0 to 56, with higher scores indicating better balance.

Timed Up and Go Test (TUG): A measure of functional mobility and fall risk. Participants were instructed to stand from a chair, walk three meters, turn, return to the chair, and sit down. Lower completion times indicate better functional mobility.

Follow-Up Assessment: A follow-up assessment was conducted four weeks after completion of the intervention to determine

whether improvements in balance and functional mobility were retained over time. Participants were advised to continue their usual daily activities and refrain from initiating new structured exercise programs during this period.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics software. Descriptive statistics were calculated for participant characteristics and outcome measures. Continuous data were expressed as mean ± standard deviation.

To examine changes over time within each group, Repeated Measures Analysis of Variance (RM-ANOVA) was performed. To evaluate the differential effects of interventions between the two groups across three time points, a Two-Way Repeated Measures ANOVA (Mixed ANOVA) was conducted, with time as the within-subject factor and group as the between-subject factor. Bonferroni adjustment was applied for post hoc pair wise comparisons. Effect sizes were calculated using partial eta squared (η^2) to determine the magnitude of treatment effects.

RESULTS

Participant Characteristics:

Table 1: Population Characteristics

	Group 1	Group 2	Total
Age	62.54 ± 5.65	63.32 ± 4.75	62.93±5.19
Gender (M/F)	(19/9)	(14/14)	(33/23)
Moca	29.50 ± 0.83	29.50 ± 0.79	29.50 ± 0.80
Duration Of Diabetes (In Years)	7.29 ± 3.52	8.82 ± 4.41	8.05 ± 4.03
HbA1C	6.78 ± 0.84	7.03 ± 0.98	6.90 ± 0.91
MNSI- Q	5.54 ± 0.88	5.39 ± 0.73	5.46 ± 0.80
MNSI- P	3.32 ± 0.47	3.32 ± 0.47	3.32 ± 0.47
History Of Falls	1.57 ± 1.34	2.21 ± 1.19	1.89 ± 1.30
FES-I	39.79 ± 7.18	43.21 ± 5.28	41.50 ± 6.48

A total of 56 participants with diabetic peripheral neuropathy were enrolled and randomized into two groups: a land-based exercise group (n = 28) and an aquatic exercise group (n = 28). All participants completed the intervention and follow-up assessments, with no dropouts or adverse events reported during the study period.

Baseline demographic and clinical characteristics were comparable between groups, indicating successful randomization. No significant between-group differences were observed at baseline for any outcome measure.

Table 2: Intra and Inter – group Data Analysis of Outcome Measures

Outcome Measure	Timeline	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)	p-value (Intragroup – Time Effect)	p-value (Intergroup – Time × Group)
TUG (sec)	Baseline	14.857 ± 1.386	15.136 ± 1.013		
	4 Weeks	12.893 ± 1.419	12.793 ± 1.237		
	Follow-up	12.950 ± 1.405	12.914 ± 1.342	<0.001	0.128
BBS (score)	Baseline	40.89 ± 3.047	40.50 ± 3.339		
	4 Weeks	44.71 ± 3.125	45.54 ± 3.121		
	Follow-up	44.79 ± 3.521	45.86 ± 2.490	<0.001	0.049

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Timed Up and Go Test (TUG): Both groups demonstrated significant improvements in functional mobility following the 4-week intervention.

Mixed ANOVA revealed a significant main effect of time ($F(2,53) = 250.321$, $p < 0.001$, partial $\eta^2 = 0.904$), indicating substantial improvement in TUG performance from baseline to post-intervention, which was maintained at follow-up. However, neither the main effect of group ($F(1,54) = 0.021$, $p = 0.885$) nor the time × group interaction effect ($F(2,53) = 2.134$, $p = 0.128$) was statistically significant, indicating comparable improvements in both the land-based and aquatic exercise groups.

Although the aquatic group demonstrated slightly greater numerical improvements immediately following the intervention, the magnitude of change did not differ significantly between interventions.

Graph 1: Mean Timed and Go Scores

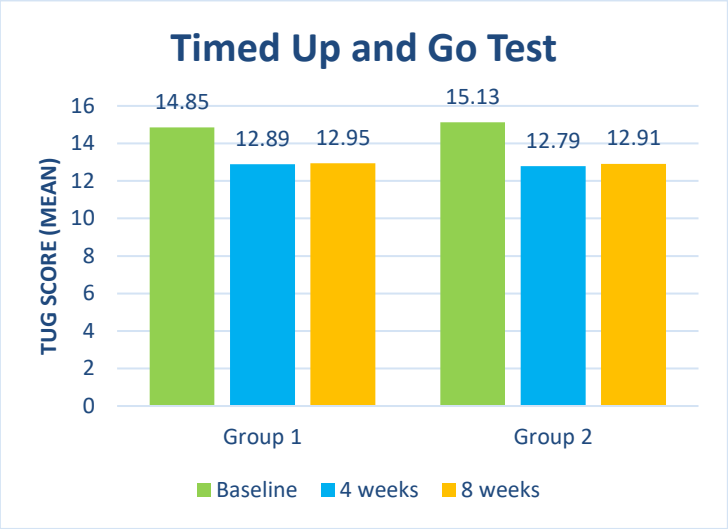
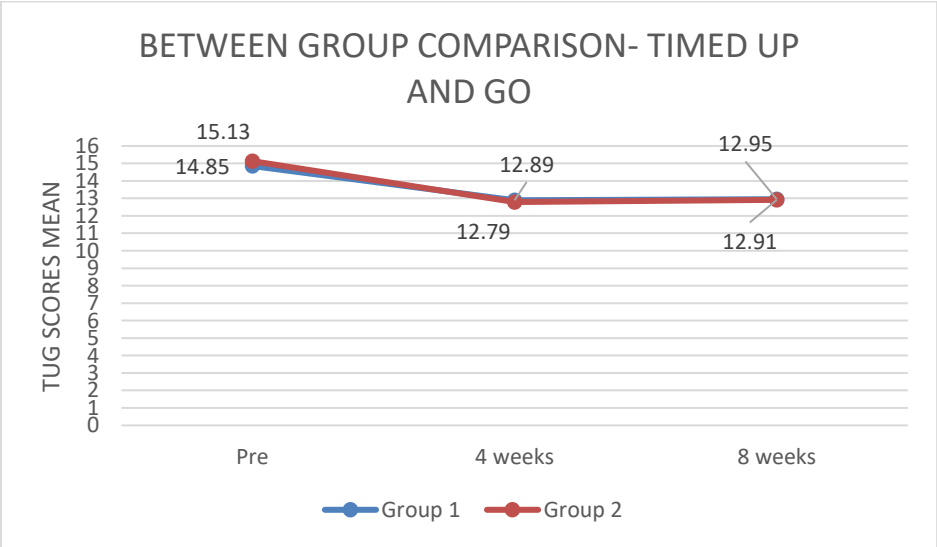


Table 3: Tug Scores Total

Time Point	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)
Baseline	14.857 ± 1.3858	15.136 ± 1.0133
4 Weeks	12.893 ± 1.4186	12.793 ± 1.2371
Follow-up	12.950 ± 1.4049	12.914 ± 1.3424

Graph 2: Between Group Comparison- Timed Up and Go Test



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Berg Balance Scale (BBS): Both groups demonstrated significant improvements in balance performance following the intervention.

Mixed ANOVA demonstrated a significant main effect of time ($F(2,53) = 160.747$, $p < 0.001$, partial $\eta^2 = 0.858$), indicating significant balance improvements following the intervention. No significant main effect of group was observed ($F(1,54) = 0.404$, $p = 0.528$), suggesting comparable overall balance improvements between the two interventions. However, a statistically significant time × group interaction was observed ($p = 0.049$), indicating that the pattern of balance improvement over time differed slightly between groups, with the aquatic exercise group demonstrating greater improvement and better retention of gains at follow-up.

Graph 3: Mean Berg Balance Score Scores

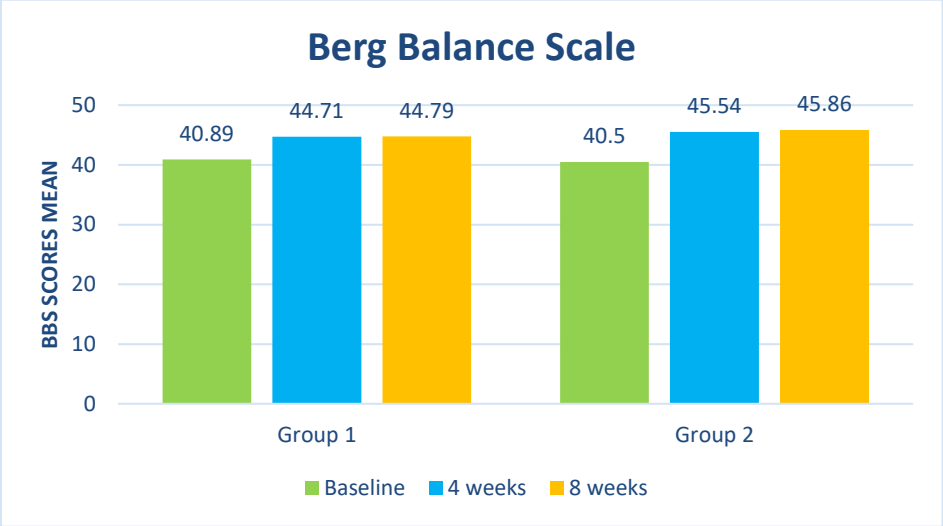
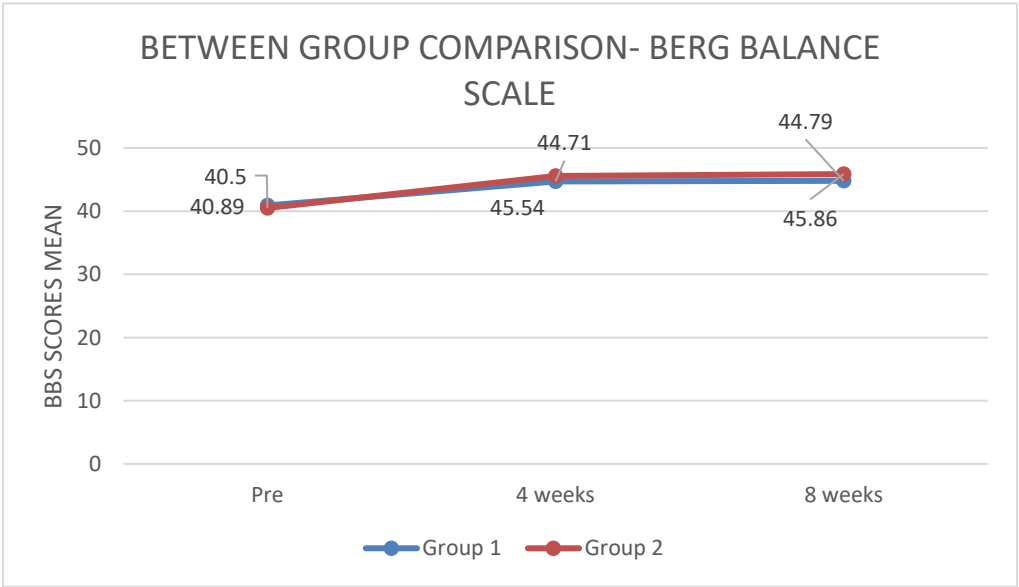


Table 4: BBS Scores Total

Time Point	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)
Baseline	40.89 ± 3.047	40.50 ± 3.339
4 Weeks	44.71 ± 3.125	45.54 ± 3.121
Follow-up	44.79 ± 3.521	45.86 ± 2.490

Graph 4: Between Group Comparison- Berg Balance Scale



Retention of Improvements: The improvements achieved following the intervention were maintained at the one-month follow-up assessment in both groups. Neither TUG nor BBS scores demonstrated clinically meaningful deterioration between post-intervention and follow-up measurements, suggesting good retention of improvements in functional mobility and balance.

Summary of Findings: Both land-based and aquatic-based FAME exercise programmes significantly improved balance and functional mobility in individuals with diabetic peripheral neuropathy. The improvements were sustained at one-month follow-up in both groups. While the aquatic exercise group demonstrated slightly greater balance improvements, particularly on the Berg Balance Scale, overall treatment effects were comparable between interventions.

DISCUSSION

The improvements observed in both land and aqua groups are attributable to the structured and progressive nature of the Fitness and Mobility Exercise (FAME) programme rather than the rehabilitation environment itself. The intervention incorporated functional strengthening, dynamic balance activities, gait-related tasks, and agility exercises that targeted impairments commonly associated with DPN.[2,18,19]

The present findings are consistent with previous studies investigating exercise interventions in DPN. Ahmad et al. demonstrated improvements in proprioception, muscular activation, and sensory function following sensorimotor and gait training,10 while Jimenez-Mazuelas et al. reported enhanced balance performance and sensory integration after a Feldenkrais-based programme.27 Similarly, Venkataraman et al. found that combined strength and balance training improved functional status in individuals with DPN.8 Collectively, these findings reinforce the role of exercise-based rehabilitation in addressing balance and mobility deficits associated with DPN.[13,20]

A notable finding of this study was the absence of clear superiority of aquatic therapy despite its recognised theoretical advantages. This finding is consistent with Zivi et al., who also reported comparable improvements following both rehabilitation approaches in individuals with peripheral neuropathies.11 Although aquatic therapy offers benefits such as reduced weight-bearing, increased sensory input through hydrostatic pressure, and resistance provided by water viscosity, these advantages did not translate into substantially superior functional outcomes when exercise content was matched across environments.[9]

Several factors may explain these findings. First, the four-week intervention duration may have been insufficient to produce differential sensory and neuromuscular adaptations between environments. Second, both groups received identical FAME-based exercises with matched intensity, progression, and frequency, thereby minimising the independent influence of the rehabilitation setting. Third, the participants primarily had mild-to-moderate DPN with preserved ambulatory ability, which may have reduced the likelihood of observing large between-group differences. Additionally, the Berg Balance Scale may have been subject to ceiling effects as participants approached higher scores after intervention. The modest sample size and the use of clinical outcome measures such as BBS and TUG may also have limited the ability to detect subtle physiological changes occurring within sensory and motor control systems.

Despite similar functional outcomes, aquatic therapy may still provide unique clinical advantages that are not fully captured by conventional assessment tools. The supportive properties of water create a safer and less intimidating environment, which may improve confidence and reduce fear associated with movement and balance challenges. Enhanced comfort and enjoyment during aquatic sessions may also encourage greater engagement and long-term adherence to rehabilitation programmes, even when objective functional outcomes are comparable to those achieved through land-based training.

From a clinical perspective, these findings support the use of either aquatic-based or land-based exercise programmes for individuals with DPN. Therefore, treatment selection may be Individualised according to patient preference, confidence levels, accessibility, weight-bearing tolerance, and available resources rather than assumptions regarding the superiority of one intervention environment over another.

Several limitations should be considered. The short intervention duration, modest sample size, and reliance on clinical outcome measures may have limited the ability to detect subtle between-group differences and long-term intervention effects. In addition, the study was conducted within a restricted geographical region, which may limit the generalizability of the findings. Variables such as exercise enjoyment, self-efficacy, and patient satisfaction were not formally assessed and may have influenced rehabilitation outcomes.

Future research should investigate longer intervention periods, extended follow-up durations, and larger multicenter samples while incorporating objective biomechanical and neurophysiological assessments to better understand the effects of aquatic and land-based rehabilitation in individuals with DPN.[11,16,20]

CONCLUSION

Both aquatic-based and land-based FAME programmes improved clinical measures of balance and functional mobility in adults with diabetic peripheral neuropathy, with benefits maintained at one-month follow-up. No clear superiority of aquatic training was observed when exercise content, intensity, and progression were matched between groups. Therefore, treatment setting may be selected based on patient preference, safety, accessibility, and weight-bearing tolerance rather than expectations of superior functional outcomes.

Future studies should include larger multicenter samples, longer intervention periods, extended follow-up (3–6 months), and objective assessments of gait, balance, fear of falling, quality of life, adherence, patient satisfaction, and cost-effectiveness.

CONFLICT OF INTEREST

The authors declare no competing interests.

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Ethical Clearance: The study commenced after obtaining approval from the Departmental Research Committee (SOP/DRC/25/033). Participants were enrolled after clearly explaining study procedures, risks, and benefits. Minor muscle soreness and temporary fatigue were mentioned as potential effects of exercise. Safety measures, such as the use of gait belts and standby assistance during challenging balance tasks, were implemented to minimize risk.

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