A Comparative Study to Analyze the Effectiveness of HIIT Versus Anaerobic Training in Improving Gait and Foot Function in Patients with Diabetic Neuropathy

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Abstract: ***Background**: Diabetic neuropathy has profound impacts on quality of life, especially for middle-aged and older adults. It causes sensory loss, pain, muscle weakness, and foot deformities, leading to disability. It arises from chronic metabolic and vascular insults to peripheral nerves. The vast majority (>90%) of these cases are type 2 diabetes (T2D), driven by obesity, sedentary lifestyle, aging, and other factors. Physical activity is a cornerstone of diabetes management in general, and its role in neuropathy is increasingly recognized. Exercise improves glycemic control, insulin sensitivity, cardiovascular fitness, and body composition in patients with type 2 diabetes. Therefore, this study evaluates changes in improving gait and foot function using the Foot Function Index (FFI) scores and Estimated Shuttle Walk Test (ESWT) score after a 12-week supervised exercise program. **Objective**: The objective of the study is to i) evaluate the effect of High-Intensity Interval Training (HIIT) on gait endurance and foot function in patients with diabetic peripheral neuropathy, ii) evaluate the effect of anaerobic (resistance-based) training on gait endurance and foot function in patients with diabetic peripheral neuropathy, iii) determine which exercise intervention is more effective in improving gait performance and foot function in patients with diabetic peripheral neuropathy. **Method**: 60 patients diagnosed with the diabetic neuropathy by Physiotherapy department, neurology or neurosciences department OPD were initially assessed for the inclusion or exclusion criteria. Prior to the treatment procedure patient are oriented to the study. Participants are divided into 2 groups and both groups assessed for the pre test parameter. Outcome measure: Foot Function Index (FFI) scores and Estimated Shuttle Walk Test (ESWT) score is used for measuring pre and post intervention evaluation. **Results**: Group comparison of post-intervention outcomes. For the Foot Function Index, Group A (HIIT) achieved a mean post-test score of 34.90 ± 1.83, compared to 43.57 ± 2.10 in Group B (Anaerobic). The mean difference of 8.67 points in favor of the HIIT group was statistically significant (t = 17.08, p < 0.001), indicating that HIIT produced superior improvements in foot function and for the Estimated Shuttle Walk Test, Group A recorded a mean post-test distance of 319.17 ± 11.75 m, compared to 278.00 ± 7.80 m for Group B; a mean difference of 41.17 m. This difference was also statistically significant (t = 15.99, p < 0.001), confirming that HIIT led to greater gains in walking endurance relative to anaerobic training. **Conclusion**: The present study found that both HIIT and anaerobic training resulted in significant improvements in gait endurance and foot function following a 12-week exercise program. Findings indicate that structured and supervised exercise programs can play an important role in improving functional mobility in individuals with diabetic peripheral neuropathy. Regular exercise may help improve walking ability, physical endurance, and foot function, which are essential for maintaining independence and improving quality of life in patients with this condition.***

Keywords: Diabetic Neuropathy, HIIT (High-Intensity Interval Training), anaerobic training

1. Introduction

Diabetes mellitus (DM) is a rapidly growing global health problem. As of 2024, roughly 11.1% of adults (20–79 years) worldwide have diabetes – approximately 589 million people – with projections rising to 853 million by 2050(1). The vast majority (>90%) of these cases are type 2 diabetes (T2D), driven by obesity, sedentary lifestyle, aging, and other factors (2). The prevalence of T2D increases sharply with age, and middle-aged or older adults (commonly 40–75 years) carry a disproportionate burden of disease (3). A major reason for concern in DM is the high rate of complications. Among these, diabetic peripheral neuropathy (DPN) is one of the most common and debilitating (4). DPN affects up to half of patients with T2D at some point in their lives. It may even be present at the time of diabetes diagnosis in a notable minority (10–20%) of cases (5). In type 2 diabetes, distal symmetric polyneuropathy is the predominant form, characterized by "stocking-glove" sensory loss starting in the feet and hands. DPN is thus a common sequela of long-standing hyperglycemia (6). Studies indicate that roughly 30–50% of people with diabetes ultimately develop neuropathic changes (7). This high prevalence makes DPN one of the leading causes of morbidity in the diabetic population (8). Diabetic neuropathy has profound impacts on quality of life, especially for middle-aged and older adults. It causes sensory loss, pain, muscle weakness, and foot deformities, leading to disability.

The neural damage in DPN profoundly alters foot structure and function. Sensory loss in the feet means minor injuries or abnormal pressures go unnoticed, predisposing to ulcers. Motor denervation leads to muscle weakness and atrophy, particularly in the intrinsic foot muscles and distal leg muscles. Chronic hyperglycemia also stiffens connective tissue: advanced glycation can reduce tendon elasticity, limiting joint range of motion (e.g., the Achilles tendon becomes stiffer).(9) As a result, common structural changes include claw-toe deformities, high or collapsed arches, and decreased ankle dorsiflexion. (10) For instance, diabetic patients often exhibit a collapsed medial longitudinal arch and increased midfoot rigidity, which, in turn, elevates plantar pressure under the forefoot. Equally important, the intrinsic foot muscles atrophy first in neuropathy, reducing the foot's dynamic support and shock absorption. In the lower limb, calf muscle atrophy and weakness lead to foot drop and an impaired push-off phase of gait.(11)These biomechanical changes cause readily observable gait abnormalities. DPN patients typically walk more slowly, with shorter step and stride lengths, longer double-support and stance times, and a more cautious, shuffling pattern. (12) Gait dysfunction also heightens fall risk and disability. Studies have shown that DPN patients exhibit impaired balance and slower reaction times, making them roughly twice as likely to fall as non-neuropathic diabetics. Muscle weakness (particularly in ankle dorsiflexors and plantarflexors) and loss of sensation diminish postural stability, so even routine tasks like walking on uneven ground or climbing stairs can precipitate a fall. (13) Recurrent falls in this population contribute to fractures and further immobility. Moreover, fear of falling may lead some patients to reduce activity, setting up a vicious cycle of deconditioning. Physically, exercise addresses the core deficits of DPN. Strengthening and balance exercises improve muscle power and proprioception, helping compensate for sensory loss. Aerobic training enhances cardiovascular support to the nerves and muscles. For example, targeted walking and balance programs have reduced postural sway and fall risk in patients with neuropathy. In practical terms, neuropathic patients who engage in appropriate exercise often walk faster, farther, and with greater stability than sedentary peers. Study found that DPN patients who undertook supervised exercise increased their daily step counts and walking distances, which directly translated into improved function. These data underscore that maintaining activity can preserve mobility: exercise is not only safe in DPN but can reverse or mitigate the trajectory of gait decline. (14,15,16,17) Nonetheless, the optimal exercise prescriptions for DPN – in terms of intensity, modality, and targets – remain under investigation. What is clear is that sedentary behavior accelerates neuropathic deterioration: the presence of neuropathy correlates with significantly lower daily activity levels. Therefore, any intervention that can safely increase activity, improve strength, or enhance balance could have a meaningful clinical impact. This motivates the current interest in comparing different training paradigms (e.g., high-intensity interval training vs. strength training) for patients with neuropathic conditions. (18)

HIIT's relevance to diabetes management is now well-recognized. It is often promoted as a "time-saving" alternative for people who find long workouts impractical. In fitness surveys, interval training has ranked among the top global exercise trends, reflecting its popularity and documented efficacy. Importantly, early evidence suggests that HIIT is safe for older or metabolically compromised patients. (22) High-intensity interval training (HIIT) is an exercise strategy characterized by brief bursts of vigorous effort interspersed with recovery periods. In practice, a HIIT session might involve short "all-out" or near-maximal efforts, typically exceeding 85–90% of maximal heart rate or oxygen uptake, alternating with passive or low-intensity intervals. (19, 20) For instance, Tabata-style HIIT consists of 8 cycles of 20 seconds of near-maximal effort (≈170% of maximal power output) followed by 10 seconds of rest; classical protocols also include multiple 4-minute bouts at 85–95% VO_2max with a few minutes of active recovery. Sprint interval training (SIT) is an extreme form of HIIT that involves "all-out" 20–30-second sprints (100–120% of maximal running speed) with brief rest. (21)

The primary aim of resistance (anaerobic) training is to build muscle strength and size. Repeated overload causes muscle fiber hypertrophy and increased motor unit recruitment. This training also enhances bone density and tendon strength, which is especially relevant for diabetic patients with connective tissue stiffness. Significantly, resistance exercise improves the lean-to-fat mass ratio: greater muscle mass raises basal metabolic rate and facilitates glucose disposal. (23) "Anaerobic training" generally refers to high-intensity exercises that rely primarily on non-oxidative energy pathways. In the context of diabetes, this often means resistance training (weightlifting, resistance bands, body-weight exercises) and similar power-oriented activities. Unlike steady-state aerobics, these workouts involve short, intense muscle contractions (e.g., lifting a heavy weight) typically lasting 5–30 seconds, repeated for multiple sets. Clinically, incorporating anaerobic training in diabetes care is recommended. Guidelines advocate 2–3 days per week of moderate-intensity muscle-strengthening activities for adults with DM. Evidence shows that such activities improve not only strength but also overall metabolic health. For diabetic patients, added benefits include enhanced gait stability and reduced fall risk due to stronger postural muscles. It is worth noting that many activities of daily living (such as carrying groceries, climbing stairs, and rising from chairs) are inherently anaerobic. Encouraging purposeful resistance exercise – from lifting weights to functional "elderly-friendly" tasks – can thus have an outsized impact on independence in DPN. (24)

In practice, this means the question at hand, which is more effective for gait and foot function in DPN: HIIT or anaerobic training, remains unanswered in the literature. Existing studies hint at potential: HIIT clearly boosts insulin sensitivity and might improve vascular supply to nerves, whereas resistance training builds the musculature underlying gait. But without direct comparative trials examining gait speed, stride parameters, plantar pressures, and foot strength as outcomes, clinicians lack evidence-based guidance. Thus, the current state of knowledge is incomplete. It is precisely this gap, the absence of robust comparative data on HIIT versus anaerobic (resistance) interventions for gait and foot outcomes that motivates further research. Establishing which modality (or combination) best preserves mobility and foot health in middle-aged and older diabetic patients could have substantial implications for preventing falls, ulcers, and functional decline. (25)

2. Materials and Methodology

Methodology

Study Design: Comparative study.

Sample Design: Simple Sampling technique.

Study Setting: Patient were treated 3 times per week for 12 week at Department of physiotherapy, Pacific Medical college and hospital. UDAIPUR

Study Population: Male & Female both the patients of diabetic neuropathy of age group of 35-65 years of age related injury or trauma and are willing to participate in this study.

Sample Selection: 60 Patient will be selected and Will be assessed for the pre-test parameter.

Study Duration: one year

Sample Size: 60 participants

Treatment Duration: single session 45-60 minutes for (3 days per week) for 12 weeks.

Selection Criteria

Inclusion Criteria:
- Aged between 30 and 65 years.
- Patient with both types of DM
- Independent walking ability for at least 10 m

Exclusion Criteria:
- History of cerebrovascular accident
- Lower limb nerve injury
- Presence of an active planter ulcer
- History of surgical procedure at the knee, ankle, or hip, or indication of surgery throughout the intervention period
- Arthroplasty and/or orthosis of the lower limb
- Dementia or inability to give consistent information
- Major vascular complication
- Other neurological disorders

3. Procedure

Permission for conduct of research is taken from the institutional ethical committee of PMCH**(PMU/IEC/MPT/2025)**, Pacific medical university bhilo ka bedla Udaipur (RAJ).

Individuals Diagnosed with diabetic neuropathy by Physiotherapy department, neurology or neurosciences department OPD; initially assessed for the inclusion or exclusion criteria. Prior to the treatment procedure, all participants were informed about the purpose, procedures, potential benefits, and possible risks of the study. Written informed consent was obtained from each participant prior to enrollment. Following the consent process, the participants were randomly allocated into two groups. 60 subjects were selected on the basis on inclusion criteria and randomly divided into Group-A and Group -B
- Group A (n=30) treat with HIIT Program
- Group B (n=30) treat with Anaerobic Training Program.

Group A: HIIT Program
Exercise Training Protocol
Phase 1 (Weeks 1–3)
5 min warm-up → 20 min continuous aerobic exercise → 5 min recovery
Phase 2 (Weeks 4–8)
5 min warm-up → 1-min sprint + 5-min active recovery (×4 sets) → 5 min cool-down
Phase 3 (Weeks 8–12)
5 min warm-up → 6 × 1-min sprints with 4-min active recovery → cool-down
Exercise Components

Exercise Category	Description
Foot Exercises	Sitting foot exercises using a ball
Core Training	Core stabilization exercises
Lower Limb Strengthening	Partial squats and functional lower-limb exercises

Group B: Anaerobic Training Program

Exercise Intervention Protocol

Range of Motion (ROM) Exercises - Passive stretching of toes, hallux, calf, and hamstrings (3 repetitions × 30 seconds for each muscle group)

Muscle Strengthening - Intrinsic and extrinsic foot muscle strengthening using manual resistance (1 × 30 repetitions), Heel and toe standing exercises (1 × 20 repetitions)

Balance Training - Single-leg and double-leg stance (eyes open and eyes closed) 3 × 30 seconds each exercise, Balance board exercises (3 × 30 seconds)

Gait Training - Walking on heels, toes, medial and lateral borders of the foot, Progressive walking, Tandem walking (Up to 30 meters without rest)

Home Exercise Protocol - Stretching and strengthening exercises

4. Data Analysis and Results

Study found that both HIIT and anaerobic training resulted in significant improvements in gait endurance and foot function following a 12-week exercise program. Findings indicate that structured and supervised exercise programs can play an important role in improving functional mobility in individuals with diabetic peripheral neuropathy.

Results are presented as for the Foot Function Index, Group A (HIIT) achieved a mean post-test score of 34.90 ± 1.83, compared to 43.57 ± 2.10 in Group B (Anaerobic). The mean difference of 8.67 points in favor of the HIIT group was statistically significant ($t = 17.08$, $p < 0.001$), indicating that HIIT produced superior improvements in foot function.

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For the Estimated Shuttle Walk Test, Group A recorded a mean post-test distance of 319.17 ± 11.75 m, compared to 278.00 ± 7.80 m for Group B; a mean difference of 41.17 m. This difference was also statistically significant ($t = 15.99$, $p < 0.001$), confirming that HIIT led to greater gains in walking endurance relative to anaerobic training.

Collectively, these between-group results indicate that HIIT was significantly more effective than anaerobic training in improving both foot function and functional walking capacity in adults with diabetic peripheral neuropathy.

Table 1: Age Distribution of Participants

Age Group (Years)	Group A (HIIT) n (%)	Group B (Anaerobic) n (%)	Total n (%)
45–50	13 (21.7%)	13 (21.7%)	26 (43.3%)
51–55	8 (13.3%)	8 (13.3%)	16 (26.7%)
56–60	6 (10.0%)	6 (10.0%)	12 (20.0%)
61–65	3 (5.0%)	3 (5.0%)	6 (10.0%)
Total	30 (50%)	30 (50%)	60 (100%)

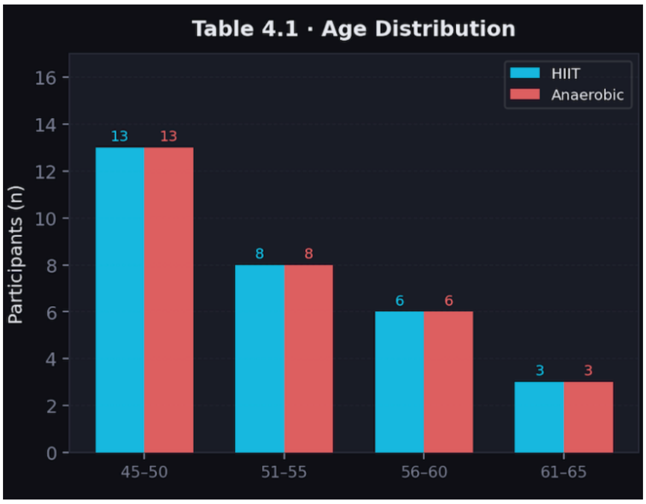


Table 2: Gender Distribution of Participants

Gender	Group A (HIIT) n (%)	Group B (Anaerobic) n (%)	Total n (%)
Male	14 (23.3%)	13 (21.7%)	27 (45.0%)
Female	16 (26.7%)	17 (28.3%)	33 (55.0%)
Total	30 (50%)	30 (50%)	60 (100%)

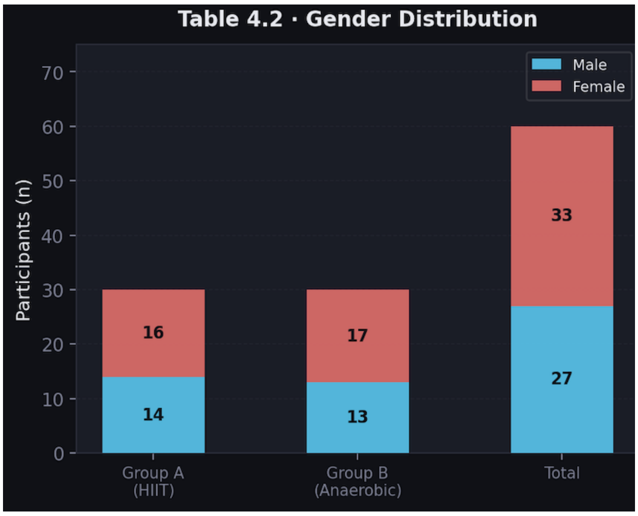
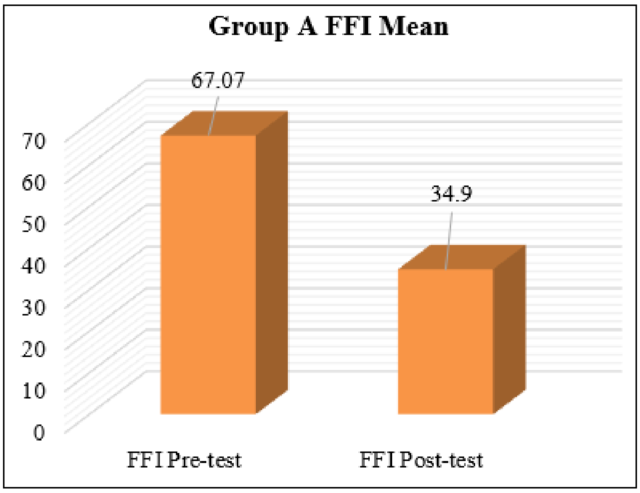


Table 3: Group A (HIIT) – Foot Function Index (FFI) Pre and Post Intervention

Variable	N	Mean	SD	Mean Difference	t-value	p-value
FFI Pre-test	30	67.07	2.32	32.17	252.08	<0.001 Significant
FFI Post-test	30	34.90	1.83			



Graph 3: Group A (HIIT) – Foot Function Index (FFI)

Table 3 presents the within-group comparison of FFI scores for the HIIT group. The mean FFI score declined from 67.07 ± 2.32 at baseline to 34.90 ± 1.83 following the 12-week intervention a mean reduction of 32.17 points. Since lower FFI scores denote superior foot function, this reduction reflects a clinically meaningful improvement in functional foot status among participants with diabetic neuropathy. The paired t-test yielded $t(29) = 252.08$, $p < 0.001$, confirming that the improvement was highly significant. These findings provide strong evidence that HIIT substantially enhanced foot function over the intervention period.

Table 4: Group A (HIIT) – Estimated Shuttle Walk Test (ESWT) Pre and Post Intervention

Variable	N	Mean	SD	Mean Difference	t-value	p-value
ESWT Pre-test	30	204.53	8.39	114.63	171.44	<0.001 Significant
ESWT Post-test	30	319.17	11.75			

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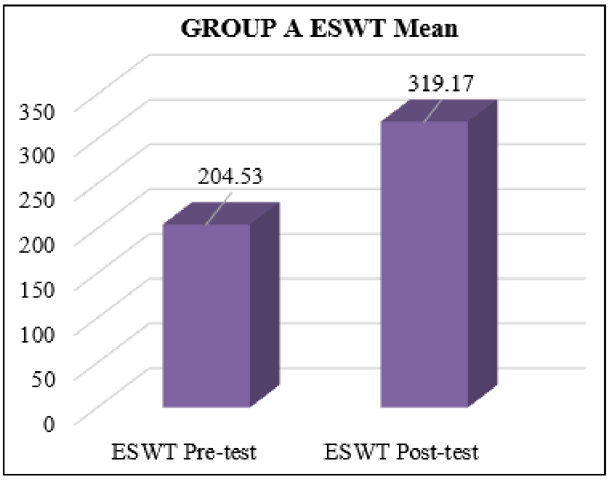


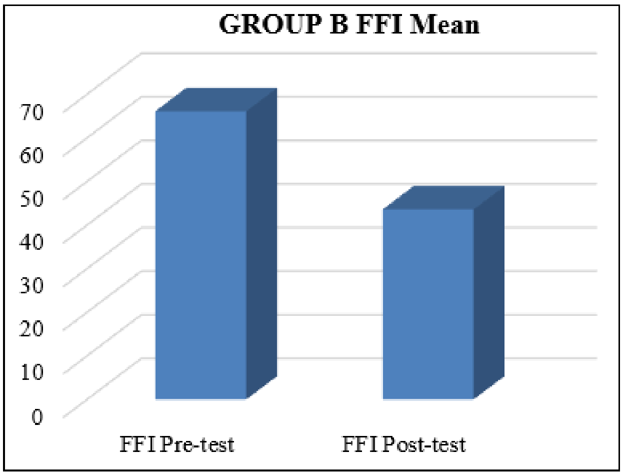
Graph 4: Group A (HIIT) – Estimated Shuttle Walk Test (ESWT)

Table 4 presents within-group ESWT performance for Group A. Mean walking distance increased from 204.53 ± 8.39 m at pre-test to 319.17 ± 11.75 m at post-test, a mean gain of 114.63 m. This represents a 56.1% improvement in walking endurance over the 12-week HIIT program.

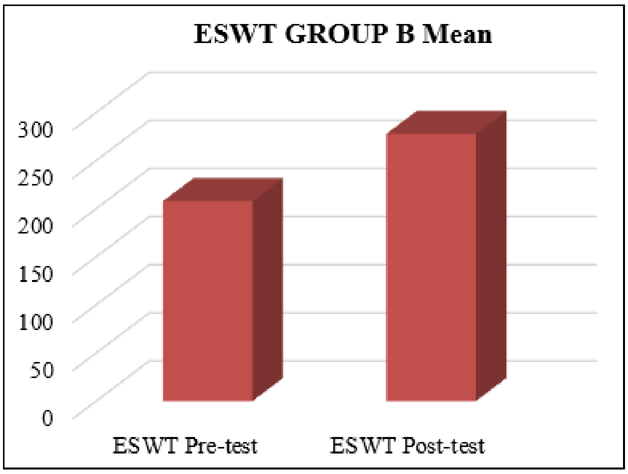
The paired t-test yielded t (29) = 171.44, $p < 0.001$, indicating a highly significant improvement in aerobic walking capacity. These results suggest that HIIT is an effective modality for enhancing functional mobility in individuals with diabetic peripheral neuropathy.

Table 5: Group B (Anaerobic Training) – Foot Function Index (FFI) Pre and Post Intervention

Variable	N	Mean	SD	Mean Difference	t-value	p-value
FFI Pre-test	30	66.1	2.41	22.53	181.12	<0.001 Significant
FFI Post-test	30	43.57	2.1			



Graph 5: Group B (Anaerobic Training) – Foot Function Index (FFI)



Graph 6: Group B (Anaerobic Training) – Estimated Shuttle Walk Test (ESWT)

Table 5 presents the within-group FFI comparison for the Anaerobic training group. The mean FFI score decreased from 66.10 ± 2.41 at baseline to 43.57 ± 2.10 post-intervention, representing a mean difference of 22.53 points. This reduction indicates improvement in foot function following the 12-week anaerobic training program.

The paired t-test yielded t(29) = 181.12, $p < 0.001$, confirming a statistically significant improvement. While the magnitude of change is notable, it is comparatively smaller than that observed in the HIIT group (32.17 points), suggesting differential efficacy between training modalities.

Table 4.6: Group B (Anaerobic Training) – 6 min Shuttle Walk Test (Estimated SWT) Pre and Post Intervention

Variable	N	Mean	SD	Mean Difference	t-value	p-value
ESWT Pre-test	30	208	7.65	70	551.82	<0.001 Significant
ESWT Post-test	30	278	7.8			

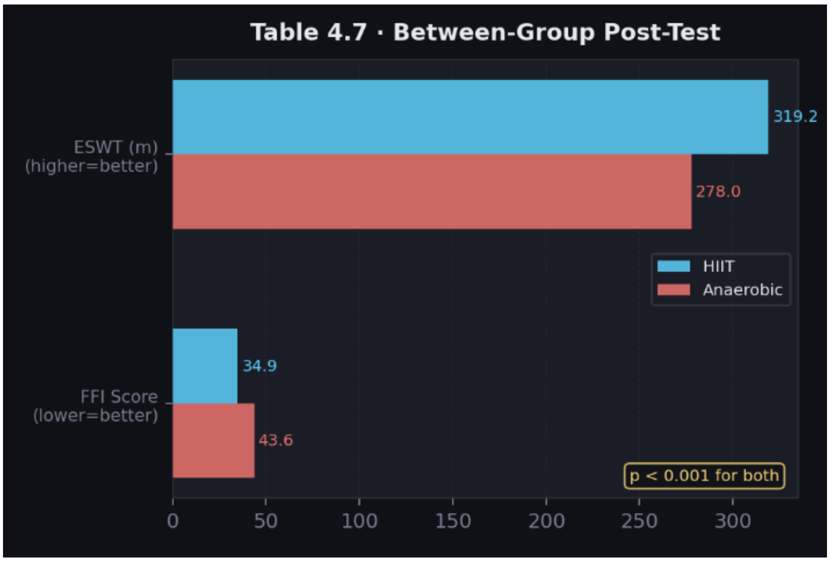
Table 4.6 presents the within-group ESWT performance for Group B. Mean walking distance improved from 208.00 ± 7.65 m at pre-test to 278.00 ± 7.80 m at post-test, reflecting a mean gain of 70.00 m (a 33.7% increase). This demonstrates that anaerobic training produced a meaningful improvement in walking endurance over the intervention period.

The paired t-test yielded t(29) = 551.82, $p < 0.001$, confirming a highly significant improvement. Nevertheless, the magnitude of ESWT gain in Group B (70.00 m) is substantially lower than that of Group A (114.63 m), indicating a superior aerobic capacity benefit with HIIT.

Table 7: Between-Group Comparison of Post-Test Scores

Variable	Group A (HIIT) Mean ± SD	Group B (Anaerobic) Mean ± SD	Mean Difference	t-value	p-value
FFI	34.90 ± 1.83	43.57 ± 2.10	8.67	17.08	<0.001*
ESWT (m)	319.17 ± 11.75	278.00 ± 7.80	41.17	15.99	<0.001*

Note. *p < 0.001 (independent samples t-test, two-tailed). Lower FFI = better foot function; higher ESWT = better walking endurance.



5. Discussion

The improvements observed in both groups in the present study highlight the important role of exercise as a key component of rehabilitation in individuals with diabetic peripheral neuropathy. Diabetic neuropathy develops gradually due to long-term metabolic and neuromuscular changes associated with prolonged hyperglycemia. These changes lead to sensory loss, muscle weakness, impaired balance, and reduced coordination, which negatively affect walking ability and functional independence. Because these impairments develop slowly over time, improvements in functional ability occur gradually as well. The improvements observed after 12 weeks of structured exercise training in the present study suggest that regular and supervised exercise can produce meaningful changes in walking endurance and foot function even within a relatively short intervention period. Exercise programs can help improve muscle strength, joint mobility, circulation, and neuromuscular coordination, which together contribute to better walking performance and improved functional capacity in individuals with diabetic neuropathy.

The findings of the present study are supported by previous research that has emphasized the benefits of exercise therapy for patients with diabetic peripheral neuropathy. Melese et al. (2020) conducted a systematic review to evaluate the effectiveness of exercise therapy on gait function in individuals with diabetic peripheral neuropathy. The authors conducted a comprehensive literature search and included 9 randomized controlled trials involving 370 participants. The methodological quality of the studies was assessed using the PEDro scale and the GRADE approach, and the overall quality of the evidence ranged from moderate to high. Due to differences in exercise protocols and outcome measures across the included studies, the authors conducted a qualitative synthesis rather than a meta-analysis.

The review found that 8 of the 9 included studies reported significant improvements in gait function following exercise interventions compared with control groups or usual care. The exercise programs used in these studies commonly included strengthening, balance, range-of-motion, stretching, flexibility, and gait training. Several studies also used multi-component exercise programs that combined different types of exercises to address multiple impairments associated with diabetic neuropathy.

Gait function in the reviewed studies was assessed using commonly used clinical outcome measures, including the Six-Minute Walk Test (6MWT), the 10-Meter Walk Test, and the Tinetti Performance-Oriented Mobility Assessment. These outcome measures are widely used to evaluate walking endurance, walking speed, balance, and overall mobility in patients with neurological and metabolic conditions. The authors concluded that structured exercise therapy is effective in improving gait performance and functional mobility in individuals with diabetic peripheral neuropathy and recommended that exercise programs be included as an important part of rehabilitation management for this population.

The findings of the present study are consistent with these observations, as both exercise interventions led to improvements in walking endurance and foot function after the intervention period. This further underscores the importance of regular, structured exercise programs in improving functional outcomes in patients with diabetic peripheral neuropathy.

The findings of the present study are also supported by Holmes and Hastings (2021), who discussed the role of exercise training in managing impairments associated with diabetic peripheral neuropathy. The authors explained that diabetic neuropathy leads to muscle atrophy, muscle weakness, sensory deficits, and impaired balance, particularly in the lower extremities. These impairments reduce patients' ability to maintain stable posture and walk efficiently, ultimately affecting gait performance and overall functional mobility. Holmes and Hastings (2021) highlighted that exercise training can help address these impairments by improving neuromuscular strength, coordination, balance, and overall physical function. Aerobic exercise was reported to improve cardiovascular fitness and endurance, while resistance training was shown to enhance lower-limb muscle strength and stability. As a result, exercise interventions can play an important role in improving walking ability and reducing functional limitations in individuals with diabetic peripheral neuropathy.

Holmes and Hastings (2021) further explained that different types of exercise provide different functional benefits for individuals with diabetic peripheral neuropathy. According to their review, aerobic exercise primarily improves cardiovascular fitness and endurance, thereby enhancing walking ability and overall mobility. In contrast, resistance-based exercise focuses on improving muscle strength and joint stability, which are important for maintaining proper foot support, balance, and control during gait. These explanations align closely with the findings of the present study, which showed that both HIIT and anaerobic training significantly improved gait endurance and foot function. HIIT may have improved walking endurance through cardiovascular and metabolic adaptations, while anaerobic training may have enhanced foot function by strengthening the lower-limb and intrinsic foot muscles. Therefore, the improvements observed in both groups are consistent with the mechanisms described by Holmes and Hastings (2021), supporting the use of different exercise approaches to address multiple functional deficits in patients with diabetic peripheral neuropathy.

High-Intensity Interval Training (HIIT) involves short periods of high-intensity exercise alternated with recovery periods, which challenge both aerobic and anaerobic energy systems. The improvement in walking endurance observed in the HIIT group in the present study may be related to better cardiovascular efficiency, improved muscle oxygen utilization, and improved metabolic regulation developed during the training program. Similar findings were reported by Alarcón-Gómez et al. (2020), who investigated the effects of a short-term HIIT program in individuals with diabetes. Their study reported improvements in lower-limb muscle power, ankle mobility, and dynamic balance following the HIIT intervention. Although their research was conducted in patients with type 1 diabetes, the physiological adaptations observed in their study support the functional improvements seen in the HIIT group of the present study.

Anaerobic or resistance training primarily focuses on improving muscle strength, power, and neuromuscular control. In individuals with diabetic peripheral neuropathy, intrinsic foot muscles and lower-limb muscles often become weak due to nerve damage, which affects stability and walking efficiency. Strengthening these muscles can improve foot stability, weight distribution, and push-off during walking, thereby enhancing gait performance. In the present study, the significant improvement in Foot Function Index (FFI) scores in the anaerobic training group supports this mechanism. Similar findings were reported by Monteiro et al. (2022), who examined the effects of a foot–ankle therapeutic exercise program in individuals with diabetic peripheral neuropathy. Their study showed improvements in gait speed, ankle mobility, and foot function following the exercise intervention.

However, not all studies report uniform improvements across all functional outcomes. For example, Monteiro et al. (2022) reported that although participants showed improvements in gait speed and ankle mobility, there was no significant change in daily step count. This finding contrasts slightly with the present study, which observed overall functional improvements. The difference between these findings may be due to variations in exercise intensity, duration, and the types of exercises used, as the present study included whole-body exercise training programs.In contrast, Monteiro et al.'s study mainly focused on localized foot–ankle exercises.

Some researchers have suggested that high-intensity exercise may not always be suitable for older adults with diabetic neuropathy, mainly due to concerns related to safety and the risk of injury. For example, Gracia-Sánchez et al. (2025) reported that although exercise programs can improve balance, physical function, and mobility in individuals with diabetic peripheral neuropathy, the evidence regarding long-term safety, ulcer prevention, and adverse events remains inconsistent. These concerns are particularly important for patients with reduced sensation in the feet, as they may not easily detect pressure or injury during exercise. However, in the present study, no adverse events were reported during the intervention period, suggesting that well-designed and supervised HIIT programs can be safely performed by patients with diabetic neuropathy when proper monitoring, progression, and professional supervision are provided.

Some studies have also emphasized the benefits of resistance-based exercise for improving foot-related outcomes in patients with diabetic neuropathy. For instance, Saeed et al. (2024) reported that strength-based training led to greater improvements in foot stability and balance than aerobic training alone. Strength training can help improve the function of the intrinsic foot muscles and lower-limb musculature, which are often weakened in patients with neuropathy due to nerve damage. Improved muscle strength can enhance foot support, weight distribution, and postural stability, which are essential for safe and efficient walking. The findings of the present study partially support these observations, as the anaerobic training group showed improvements in foot function, as measured by the Foot Function Index (FFI). However, unlike some previous studies that focused mainly on resistance training, the current study also demonstrated that HIIT improved walking endurance and functional mobility.

Overall, this study's findings suggest that both HIIT and anaerobic training are effective interventions for improving gait performance and foot function in individuals with diabetic peripheral neuropathy. The results indicate that HIIT may provide greater benefits for improving walking endurance and overall mobility. Atthe same time, anaerobic training may contribute more to improving foot stability, muscle strength, and neuromuscular control. These results are consistent with the observations of Khurshid et al. (2025), who reported that different types of exercise provide distinct functional benefits in patients with diabetic neuropathy. According to their findings, aerobic-based training may be more effective for improving gait performance and cardiovascular endurance.In contrast, resistance-based training may be more beneficial for improving muscle strength, balance, and foot stability. Therefore, exercise programs for patients with diabetic peripheral neuropathy should be carefully designed and tailored to each patient's specific functional limitations and rehabilitation goals.

6. Conclusion

The present study found that both HIIT and anaerobic training resulted in significant improvements in gait endurance and foot function following a 12-week exercise program. Participants in both groups demonstrated a reduction in Foot Function Index (FFI) scores, indicating decreased foot pain, disability, and activity limitations related to foot problems. A lower FFI score reflects better foot function and improved ability to perform daily activities without discomfort.

Similarly, walking endurance improved in both groups, as evidenced by increased Estimated Shuttle Walk Test (ESWT) distance after the intervention period. This means that participants were able to walk longer distances and tolerate physical activity better after completing the training program. The improvement in walking performance may be related to greater muscle strength, improved joint mobility, increased cardiovascular endurance, and enhanced neuromuscular coordination, all of which are developed through regular exercise training.

Overall, these findings indicate that structured and supervised exercise programs can play an important role in improving functional mobility in individuals with diabetic peripheral neuropathy. Regular exercise may help improve walking ability, physical endurance, and foot function, which are essential for maintaining independence and improving quality of life in patients with this condition.

Based on these findings, it is suggested that physiotherapists and rehabilitation professionals consider incorporating structured exercise programs that include HIIT and resistance-based exercises into the rehabilitation management of patients with diabetic peripheral neuropathy. Such exercise interventions may help improve walking ability, muscle strength, balance, and functional independence, thereby enhancing the overall quality of life of individuals living with diabetic neuropathy.

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