Rehabilitation Outcomes in Diabetic Peripheral Neuropathy: An Evidence-Based Physiotherapy Approach for Functional Improvement – Case

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Abstract

Background: Diabetic Peripheral Neuropathy (DPN) is a prevalent and debilitating complication of diabetes mellitus (DM), affecting up to 70% of individuals with diabetes. DPN impairs motor and sensory functions, leading to pain, muscle weakness, and functional limitations that severely affect the quality of life. Effective rehabilitation strategies, including physiotherapy, are essential for improving these functional outcomes. Methods: This study assessed the effectiveness of a 12-week evidence-based physiotherapy rehabilitation program designed to improve the functional status of a 48-year-old female patient with DPN. The intervention included Transcutaneous Electrical Nerve Stimulation (TENS), range of motion (ROM) exercises, strengthening exercises, balance training, and gait improvement, administered over 45 physiotherapy sessions. Progress was measured using the Visual Analog Scale (VAS), Berg Balance Scale (BBS), and the Timed Up and Go (TUG) test. Results: Following the 12-week intervention, the patient reported significant improvements in pain reduction, with VAS scores decreasing from 9/10 to 4/10. Sensory function improved from impaired to intact, as assessed through light and deep touch sensation tests. Balance scores on the BBS increased from 22 to 48, indicating substantial gains in stability. Gait speed, measured using the TUG test, improved from 35 seconds to 13 seconds. Additionally, there were marked improvements in ROM, muscle strength, and overall functional abilities. Conclusion: The study demonstrates the effectiveness of a structured physiotherapy rehabilitation program in reducing neuropathic pain and improving functional outcomes in patients with DPN. TENS, combined with exercise-based interventions, significantly enhanced pain management, balance, and gait. Long-term monitoring and continued physiotherapy may further optimize the patient's functional status and quality of life.

Keywords: Diabetic Peripheral Neuropathy (DPN), Transcutaneous Electrical Nerve Stimulation (TENS), Range of Motion (ROM), Physiotherapy Rehabilitation, Functional Improvement

Significance | This study highlights physiotherapy's role in managing Diabetic Peripheral Neuropathy, highlighting significant improvements in pain, balance, and mobility.

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Introduction

Diabetic Peripheral Neuropathy (DPN) is one of the most common and debilitating complications of diabetes mellitus (DM), a metabolic condition characterized by chronic hyperglycemia (Bhatt, Metha, & Kumar, 2022). Around 60% to 70% of diabetic individuals experience some form of neuropathy, with DPN being

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the most prevalent, affecting both motor and sensory nerves (Throat & Ganvir, 2015). DPN impairs sensations such as touch, temperature, and proprioception, and often leads to symptoms such as muscle stiffness, atrophy, tingling, burning sensations, and pain (Dobson et al., 2014). These symptoms can severely impact the quality of life, leading to functional limitations, depression, and increased risk of falls and injuries (Bairaktaridou et al., 2021).

Globally, approximately 75% of all peripheral neuropathies are symmetrical peripheral polyneuropathies, with DPN being the most frequent type (Bairaktaridou et al., 2021). In Bangladesh, the prevalence of DPN is notably high, with 29.4% of the population affected, significantly influencing the country's socioeconomic dynamics (Kisozi et al., 2017). Type 2 diabetes accounts for a higher incidence of peripheral neuropathy (54%) compared to other types of diabetes (45%) (Jahantigh et al., 2020). Factors such as age, obesity, smoking, poor glycemic control, and hypertension are recognized as key risk factors for DPN (Jahantigh et al., 2020).

Painful neuropathy, a subset of DPN, affects 1 in 5 diabetic patients and is particularly distressing. Nearly half of those with diabetic neuropathy experience pain, with 30-40% suffering from neuropathic pain (Jensen et al., 2021). The condition poses significant challenges for daily living, exacerbating physical and emotional burdens on patients. Given the limitations imposed by DPN on motor and sensory function, rehabilitation is often recommended as an essential intervention to restore physical capabilities and maintain quality of life (Zivi et al., 2018).

Physiotherapy, specifically exercise-based interventions, has proven to be an effective non-pharmacological approach to managing DPN. It improves glucose control, cardiovascular fitness, muscle strength, and body composition, all critical factors in preventing and managing type 2 diabetes (Kluding et al., 2012). Rehabilitation programs often include strength training, stretching, functional exercises, and gait improvement, all designed to enhance foot function and biomechanics (Jahantigh et al., 2020). Despite its complexity, physical therapy remains a vital aspect of treatment for patients with DPN, particularly in clinical settings where understanding of the condition is still evolving.

This study aims to investigate the impact of evidence-based rehabilitation on the functional status of patients with DPN. The objectives are to explore the clinical presentation of DPN, assess the role of manual therapy integrated with conventional physical therapy, and evaluate the comparative effectiveness of various treatment modalities for DPN. By identifying the most effective rehabilitation techniques, this research hopes to contribute to better clinical outcomes and improved quality of life for individuals suffering from this chronic condition.

Case Presentation

Mrs. X, a 48-year-old woman with a 12-year history of insulin-dependent diabetes, recently presented with severe pain in both her legs and feet. She described the pain as a burning, numb, and squeezing sensation, followed by cramping in her calves. On a 10-point visual analogue scale (VAS), she rated her pain as 9. The discomfort has made it difficult for her to wear shoes during the day and worsens when she uses her legs. She also experiences fatigue and balance issues when walking short distances, and she believes her sense of balance has deteriorated. However, she initially avoided seeking medical attention, attributing her symptoms to the aging process. In addition to diabetes, Mrs. X has high blood pressure and hypercholesterolemia. Upon examination, both of her feet had intact protective sensation, with no open lesions present, yet she has developed depression due to her persistent neuropathic pain. She also revealed that her mother suffers from a similar condition. Despite being on oral medications such as glikuidon, meloxicam, and ranitidine, Mrs. X saw no significant improvement and was eventually referred to a medical rehabilitation facility for physiotherapy.

A physical examination revealed impaired sensation in her lower limbs, though her upper limb sensation remained normal. Sensory testing, including light and sharp touch, confirmed the deficits in the lower extremities. Although Mrs. X's upper limbs retained normal range of motion (ROM), her lower limbs showed decreased muscle strength, particularly in the right leg. Her ankle reflexes were normal, but her gait and balance were notably affected, as assessed through tests like the Berg Balance Test and the Timed Up and Go Test.

The diagnosis of Diabetic Peripheral Neuropathy (DPN) was made following extensive clinical and diagnostic assessments, including X-rays, MRIs, CT scans, and laboratory tests such as CBC, RBS, Vitamin D levels, HLA B27, NCS, CRP, and HbA1c. Nerve conduction studies (NCS) indicated sensory polyneuropathy in both her upper and lower limbs, consistent with DPN. An MRI of the cervical spine showed degenerative changes and disc bulges at multiple levels, though without evidence of cord or root compression. A differential diagnosis ruled out other conditions, such as Guillain-Barré syndrome (GBS), cervical myelopathy, lumbar stenosis, ankylosing spondylitis, and transverse myelitis, based on physical examination, imaging, and electrophysiological studies (Table 1). Ultimately, the diagnosis of DPN was confirmed (Figure 1).

Mrs. X's primary issues include neuropathic pain and impaired sensation in both her upper and lower limbs, with more significant deficits in her lower limbs. She also has decreased range of motion, muscle strength, and balance, all contributing to a reduction in her overall functional abilities.

Figure 1. MRI finding

Figure 2. Physiotherapy intervention

Table 1. Differential diagnosis

Condition	Cues	Therapist findings
GBS	Peripheral muscle (Ascending type) weakness	Electromyography and physical examination findings negative
Cervical myelopathy	Nerve root compression UL& LL weakness	Babinski sign negative Reflex normal
Lumber stenosis	Age and Numbness in the lower limb	Sitting or flexion exercise does not relieve the symptoms
Ankylosing spondylitis	Back pain and stiffness	Age 45+, HLA-B27 negative
Transverse Myelitis	Motor weakness and sensation changes	Nerve conduction studies show DPN

Table 2. Short-term and Long-term SMART Goals for Physiotherapy Intervention

Goal	Objectives
Short term	• Provide education to the patients about her stable condition including diagnosis, treatment, and prognosis. • Reduce pain from VAS 4/10 to 9/10 in VAS. • Increase Joint ROM.
Long term	• Reduce numbness and tingling sensation. • Improve balance and coordination. • Improve functional activities (ADL). • Improve gait.
Follow up	• Home based physiotherapy intervention.

Table 3. Physiotherapy Intervention Protocol

Interventions	Dosage of interventions	Aim
Patient Education	-	• Make the patient more careful about the disease.
TENS	TENS on both lower limbs, 3 times per week for 20 min **(Serry et al., 2016).**	• To reduce neuropathic pain
Range of motion exercises	10 repetitions X 2 sets (with hold for 10 seconds) **(Refay et al, 2013)**	• To increase ROM
Flexibility/ Stretching exercise	**F**= 10 repetitions X 3 sets (with hold for 30 seconds) **I**= Mild to moderate **T**= 10 min **T**= upper & lower limb strengthening Hamstring, Quadriceps, calf stretch **(Mueller et al., 2013)**	• To maintain muscle flexibility
Strengthening exercise	**F**= 10 repetitions X 3 sets per week **I**= Mild to moderate **T**= 10 min **T**= upper & lower limb strengthening **(Melai et al, 2014)**	• Strengthening exercises can improve gait of diabetic patients with peripheral neuropathy
Balance training	**F**= 2 times per week **I**= Mild to moderate **T**= 45 min (including breaks) Shifting weight and crossing virtual obstacles **(Grewal, Almar, Temesgen & Kahsay, 2015)**	• Balance exercises can improve gait of diabetic patients with peripheral neuropathy
Aerobic Exercise	**F**= 3- 5 times per week (50-70%) reserve heart rate **I**= Patient tolerance **T**= 20-25min Treadmill walking Cycling Swimming **(Kluding et al., 2015)**	• Improve muscle endurance • Improve insulin sensitivity
Gait training	**F**= 3 times per week **I**= Patient tolerance **T**= 45- 60 min Bridging, sit to stand, Stepping, Staring **(Melese et al., 2020)**	• Improve DPN patients gait
Home exercise	Do the advised exercises 10 times/day	• To maintain functional performance

Table 4. Rehabilitation Outcomes After 45 Sessions

Evaluation	Initial	After 3 month
Pain	VAS 9/10	VAS 4/10
ROM	**U/L**- FROM **L/L-** **Hip:** Around (10-20)^0 Loss in all movements. **Knee:** Around (10-30)^0 loss in all movements. **Ankle:** Around (5-15)^0 loss in all movements.	**U/L**- FROM **L/L-** **Hip:** FROM **Knee:** FROM **Ankle:** FROM
Sensation	**Superficial:** Impaired **Deep:** Poor **Combined (cortical):** Right: Poor Left: Fair	**Superficial:** Intact **Deep:** Good **Combined (cortical)**: Right & left : Good
Muscle Strength (Oxford muscle grade scale)	**U/L:** Right: All muscle groups' muscle strength was 4. Left: All muscle groups' muscle strength was 5. **L/L:** **Hip flexor:** Right- 3 Left- 4 **Hip extensor:** Right- 3 Left- 4 **Knee flexor:** Right- 3 Left- 4 **Knee extensor:** Right- 3 Left- 4 **Planter flexor:** Right-3 Left-4 **Dorsi- flexor** Right-3 Left-4	**U/L:** Right & left: All muscle groups' muscle strength of U/L was 5. **L/L:** **Hip flexor:** Right- 4 Left- 5 **Hip extensor:** Right- 4 Left- 5 **Knee flexor:** Right- 4 Left- 5 **Knee extensor:** Right- 4 Left- 5 **Planter flexor:** Right-4 Left-5 **Dorsi- flexor** Right-4 Left-5
Balance (BBS) Score	22	48
TUG Score (Gait)	35 second	10 second

To achieve optimal treatment outcomes and meet the study objectives, a SMART goal (Specific, Measurable, Achievable, Relevant, Time-based) was established. This structured approach focuses on both immediate and long-term improvements in the patient's condition. The short-term goals, outlined in Table 2, emphasize patient education on their condition, including diagnosis, treatment plans, and prognosis. A key focus is on pain management, aiming to reduce the pain score from 9/10 to 4/10 on the Visual Analog Scale (VAS). Additional short-term objectives include improving joint range of motion (ROM).

The long-term goals target overall functionality, seeking to reduce numbness and tingling sensations while enhancing balance, coordination, and the ability to perform activities of daily living (ADL). Gait improvement is also a priority, with the aim of increasing the patient's stability and ease of movement. The follow-up plan involves a home-based physiotherapy program to ensure continued progress, encouraging the patient to stay engaged in their rehabilitation journey (Table 2).

Physiotherapy Intervention

A 12-week physiotherapy intervention was designed, following evidence-based manual therapy and the FIIT principle (Burnet et al., 2019) (Figure 2). The treatment protocol, as outlined in Table 3, includes patient education to increase awareness and precaution regarding the disease. A transcutaneous electrical nerve stimulator (TENS) was administered three times per week for 20 minutes to reduce neuropathic pain (Serry et al., 2016). Range of motion exercises (10 repetitions for 2 sets) were incorporated to enhance joint flexibility (Refay et al., 2013), while stretching exercises (10 repetitions for 3 sets with 30-second holds) targeted major muscle groups to maintain flexibility (Mueller et al., 2013).

Strengthening exercises (10 repetitions for 3 sets per week) aimed to improve gait and functional movement (Melai et al., 2014). Balance and gait training sessions, conducted three times per week, focused on improving walking patterns and movement mechanics through functional activities. Home exercises were prescribed to reinforce these interventions and help maintain functional performance between sessions. Throughout the treatment, the patient cooperated fully, experiencing no significant discomfort. Although satisfactory progress was achieved, the patient was advised to continue home exercises and attend monthly follow-up sessions for the next three months.

Rehabilitation Outcome

After completing 45 physiotherapy sessions, the patient reported significant improvements, as summarized in Table 4. Pain levels decreased from severe (9 cm) to moderate (4 cm) according to the 10 cm Visual Analog Scale (VAS). Sensory function, assessed through light and deep touch sensation tests, improved from impaired to intact. Balance, measured by the Berg Balance Scale (BBS), showed a marked increase from 22 to 48, indicating enhanced overall stability. Gait improvements were also evident, as the Timed Up and Go (TUG) test showed a reduction in time from 35 to 13 seconds. In addition to these improvements, the patient's range of motion and strength increased, leading to an overall boost in functional capabilities. Gait efficiency significantly improved within the 12-week intervention period, resulting in enhanced mobility and quality of life.

Discussion

By 2030, an estimated 366 million people will be affected by type 2 diabetes mellitus (DM), highlighting its significance as a critical public health issue. Diabetic Peripheral Neuropathy (DPN) is the most common complication of diabetes, affecting a substantial portion of those with the condition. The present study aimed to assess evidence-based physiotherapy rehabilitation outcomes to improve the functional status of DPN patients. Over the course of 12 weeks, neuropathic pain and sensory discomfort were targeted through the use of transcutaneous electrical nerve stimulation (TENS). The pain level, as measured on the Visual Analog Scale (VAS), decreased significantly from 9/10 to 4/10 after 45 observation sessions. These results align with other studies, such as one by Serry et al. (2016), which found that TENS led to a notable reduction in pain intensity over a six-week period, supporting its effectiveness in treating DPN.

After three months of intervention, improvements in range of motion (ROM), muscle strength, and postural balance were observed. Similar findings were reported in a randomized controlled trial (RCT) involving ROM exercises, strengthening exercises, and balance training performed three times per week for 45–60 minutes per session over eight weeks. This study demonstrated that such exercises can enhance gait in patients with DPN. Aerobic exercise has also been shown to improve body fitness and muscle endurance after 12 weeks of training. According to Kluding et al. (2015), individuals with type 2 DM experienced significant improvements in insulin sensitivity following aerobic exercise. This study further supports the benefits of a physiotherapist-recommended eight-week exercise regimen, combining aerobic and resistance exercises, which is essential for cardiovascular health, muscle mass, and body composition.

Additionally, a specialized gait and balance training program, incorporating a circuit-based approach with function-oriented strengthening exercises, has been shown to improve gait speed, balance, muscle strength, and joint mobility in DPN patients (Ahmad, Verma, Noohu, Shareef, & Hossain, 2020). This highlights the value of updated rehabilitation options for improving patient outcomes. One of the strengths of this study was the use of multiple outcome-measuring techniques to quantify the significant improvements observed in this single-subject case. Another strength was the application of a specific intervention strategy based

on a FITT (Frequency, Intensity, Time, Type) analysis, which contributed to the study's effectiveness. Long-term monitoring will be crucial to assess changes in dosage, exercise repetitions, and the patient's ability to continue a properly programmed at-home exercise regimen to maintain her quality of life. However, there were limitations to this study. One major limitation was the inability to rule out medications that may contribute to diabetic neuropathy, as certain drugs commonly prescribed for diabetes patients can induce neuropathy. Additionally, the patient continued to take medication throughout the 12-week intervention period, which may have influenced the outcomes.

Conclusion

This study demonstrated the effectiveness of a 12-week physiotherapy intervention in improving functional outcomes for a patient with Diabetic Peripheral Neuropathy (DPN). Key improvements included a significant reduction in neuropathic pain, enhanced balance, and better range of motion, muscle strength, and gait efficiency. The use of evidence-based techniques such as TENS, ROM exercises, and a structured gait and balance training program proved effective in managing DPN symptoms, aligning with previous studies (Serry et al., 2016; Kluding et al., 2015). While the intervention showed positive outcomes, long-term monitoring and adherence to home exercises are crucial for sustained improvements. Limitations include the inability to isolate the effects of medications on the patient's neuropathy and their potential impact on the study results. Overall, physiotherapy plays a vital role in enhancing the quality of life for patients with DPN by addressing both motor and sensory deficits.

Author contributions

K.A. and A.I. wrote the main manuscript and S.S.U., M.F., S.F., M.J.I., M.M.A.S., M.A., T.R.M. and A.I. prepared the supplementary files and revised the manuscript. All authors reviewed and approved the manuscript.

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Competing financial interests

The authors have no conflict of interest.

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