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Effect of TENS and Exercise on Balance and Strength in Diabetic Neuropathy: A Case Report

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Abstract

Background: Diabetic peripheral neuropathy (DPN) is a common complication of diabetes mellitus characterized by sensory impairment, neuropathic pain, muscle weakness, and balance dysfunction, which collectively increase the risk of functional limitations and falls.

Objective: To describe the clinical outcomes of a combined Transcutaneous Electrical Nerve Stimulation (TENS) and exercise intervention on pain, balance, and muscle strength in a patient with DPN.

Methods: This case report describes one female patient (n = 1), aged 59 years, diagnosed with DPN who received physiotherapy intervention for three weeks (two sessions per week). The intervention consisted of TENS and lower-extremity strengthening exercises based on the FITT principle. Outcome measures included pain intensity using the Numeric Rating Scale (NRS), muscle strength using Manual Muscle Testing (MMT), and functional mobility using the Timed Up and Go Test (TUG).

Results: After three weeks of intervention, pain intensity decreased from 6/10 to 4/10 for tenderness and from 5/10 to 3/10 for movement pain (Δ = −2). Muscle strength improved from 3/5 to 4/5 in both knee and ankle muscle groups. Functional mobility also improved, as indicated by a reduction in TUG time from 20 seconds to 16 seconds (Δ = −4 seconds), suggesting enhanced balance and mobility.

Conclusion: A combined TENS and exercise intervention may contribute to improvements in pain, muscle strength, and functional mobility in patients with DPN. These findings suggest that a combined TENS and exercise approach may support short-term improvements in functional mobility and pain management in clinical practice, although further evidence is required.

Keywords
Diabetic Neuropathies; Transcutaneous Electric Nerve Stimulation; Exercise Therapy; Postural Balance; Muscle Strength

Introduction

Diabetes mellitus remains a major global health challenge, with a rapidly increasing prevalence and substantial long-term complications affecting multiple organ systems.[1] Among these, diabetic peripheral neuropathy (DPN) is one of the most common and disabling complications, affecting up to 50% of individuals with longstanding diabetes.[2] DPN is characterized by progressive peripheral nerve damage, leading to sensory loss, neuropathic pain, and motor dysfunction, particularly in the lower extremities.[3] These impairments contribute significantly to reduced functional capacity, diminished quality of life, and an increased risk of falls and disability.[4]

From a pathophysiological perspective, DPN involves both sensory and motor components.[5] Sensory deficits, including impaired vibration, pressure, and proprioception, disrupt afferent input necessary for postural control, thereby compromising balance and gait stability.[4] In parallel, motor involvement leads to muscle weakness, particularly in distal lower limb musculature, which further exacerbates instability and functional limitations.[5] The interaction between sensory loss and motor impairment creates a multifactorial mechanism underlying balance dysfunction in patients with DPN.[5]

Physiotherapy plays a central role in addressing these impairments through non-pharmacological interventions targeting both neuromuscular and functional deficits.[6] Exercise therapy, particularly programs incorporating strength, balance, and functional training, has demonstrated beneficial effects on muscle performance, postural control, and mobility in individuals with DPN.[3,7] In addition, electrotherapy modalities such as Transcutaneous Electrical Nerve Stimulation (TENS) are frequently used for pain modulation.[8] TENS is proposed to reduce pain through mechanisms such as the gate control theory and endogenous opioid release, which may indirectly facilitate improved movement and participation in rehabilitation.[6,8]

Recent evidence suggests that multimodal physiotherapy approaches may yield greater clinical benefits compared with single-modality interventions.[9] The combination of exercise and adjunctive modalities has been associated with improvements in pain, neuromuscular function, and functional performance.[9,10] However, despite these findings, the current literature is dominated by small-scale studies and heterogeneous intervention protocols, with limited high-quality evidence specifically examining the combined effects of TENS and structured exercise on both balance and muscle strength outcomes in DPN.[6] Furthermore, most studies emphasize group-level outcomes, with relatively little attention to detailed clinical progression in individual patients within real-world settings.

Therefore, there remains a need for clinically detailed reports that illustrate the application and outcomes of combined physiotherapy interventions in patients with DPN. Such reports are particularly valuable for understanding individualized responses, short-term functional changes, and the practical implementation of treatment protocols in routine clinical practice. This case is considered clinically relevant as it illustrates the short-term functional response to a combined TENS and exercise intervention in a real-world clinical setting, where detailed individual patient progression is rarely reported.

This case report aims to describe the clinical outcomes of a combined TENS and exercise intervention on pain intensity, balance, and muscle strength in a patient with diabetic peripheral neuropathy. By presenting detailed clinical findings and functional changes over time, this report seeks to contribute to the growing body of evidence supporting multimodal physiotherapy approaches in DPN management.

Methods

This study was designed as a single-patient case report and was prepared in accordance with the CARE (CAse REport) guidelines to ensure completeness and transparency in clinical reporting. The subject was a 59-year-old female diagnosed with diabetic peripheral neuropathy (DPN) who received physiotherapy treatment at UNS Hospital. The patient presented with primary complaints of numbness, tingling, and pain in both lower extremities extending from the knees to the plantar region. The symptoms had progressively worsened and interfered with daily functional activities, particularly walking and transitional movements.

The patient had a history of diabetes mellitus; however, specific clinical details such as duration of disease, glycemic control (e.g., HbA1c), and current pharmacological management were not available in the medical record and could not be retrospectively obtained. Clinical characterization of patients with diabetic peripheral neuropathy should include key variables such as duration of diabetes, glycemic control, symptom progression, and neurological findings, as recommended by international guidelines and consensus statements.[1,4]

A comprehensive physiotherapy assessment was conducted, including subjective and objective evaluations. Pain intensity was measured using the Numeric Rating Scale (NRS), a valid and reliable instrument ranging from 0 (no pain) to 10 (worst imaginable pain).[11] Muscle strength was assessed using Manual Muscle Testing (MMT), graded from 0 to 5 based on resistance capacity.[12] Functional mobility and dynamic balance were evaluated using the Timed Up and Go Test (TUG), which is widely used to assess fall risk and mobility limitations.[13]

At baseline, the patient demonstrated moderate pain during movement and pressure, generalized lower extremity muscle weakness (MMT grade 3/5), and impaired functional mobility with a TUG score of 20 seconds, indicating an increased risk of falls. No standardized neuropathy scoring system such as DN4 or the Michigan Neuropathy Screening Instrument was applied in this case. Standardized diagnostic tools such as the Michigan Neuropathy Screening Instrument (MNSI) and DN4 questionnaire are commonly used to assess neuropathy severity and neuropathic pain in clinical settings.[14,15] In addition, detailed neurological examination findings such as reflexes, vibration sense, and proprioception were not systematically documented, which limits the clinical characterization of neuropathy severity in this case.

The intervention consisted of a combined physiotherapy program including Transcutaneous Electrical Nerve Stimulation (TENS) and therapeutic exercise, administered twice weekly over a three-week period.[8] The program was structured according to the FITT principle to ensure clarity and reproducibility.

TENS was applied for pain modulation using a conventional mode with a frequency of 80–100 Hz, pulse width of approximately 100 microseconds, and duration of 12 minutes per session.[8] Intensity was adjusted to produce a strong but comfortable sensory stimulus without visible muscle contraction.[8] Electrodes were positioned along the symptomatic regions of the lower extremities following dermatomal distribution.[8] The selection of combined TENS and exercise intervention was based on the rationale that pain reduction through TENS may facilitate improved participation in exercise, thereby enhancing neuromuscular adaptation and functional recovery.

The exercise component included lower extremity strengthening through toe raises and heel raises performed in a supported standing position. Each session consisted of 5 sets of 8 repetitions, with progression based on patient tolerance and observed performance improvements. The intervention aimed to enhance muscle strength, postural control, and functional mobility.[16,17] Exercise prescription for individuals with diabetic peripheral neuropathy typically follows established guidelines such as those from the American Diabetes Association and the American College of Sports Medicine, emphasizing progressive overload, moderate intensity, and individualized adjustment based on functional capacity and safety considerations.[16] To provide a clear overview of the intervention and assessment sequence, the study timeline is summarized in Table 1.

Table 1. Intervention and Assessment Timeline

Week	Activity Description
Week 0	Baseline assessment (NRS, MMT, TUG)
Week 1	Intervention phase: TENS + exercise (2 sessions)
Week 2	Continued intervention (2 sessions) and interim evaluation (NRS, MMT, TUG)
Week 3	Continued intervention (2 sessions) and final evaluation (NRS, MMT, TUG)

As shown in Table 1, outcome measures were assessed at three time points: baseline, mid-intervention (week 2), and post-intervention (week 3), allowing for observation of short-term clinical changes. No adverse events were reported during the intervention period, and all procedures were conducted within patient tolerance to ensure safety.

Data analysis was conducted descriptively by comparing outcome measures across time points. Changes in NRS, MMT, and TUG scores were calculated to describe trends in pain reduction, muscle strength improvement, and functional mobility. No inferential statistical analysis was performed due to the single-case design. Interpretation of clinical changes was based on observed differences over time and general clinical benchmarks reported in the literature. For pain outcomes, a reduction of approximately 2 points on the Numeric Rating Scale (NRS) is commonly considered clinically meaningful.[11] For functional mobility, improvements in Timed Up and Go (TUG) performance of approximately 3–4 seconds have been suggested as clinically meaningful in populations with mobility impairment.[13] The absence of standardized neuropathy severity assessment and incomplete clinical history represent important methodological limitations of this case report.

This case report did not require formal ethical clearance as it involved routine clinical care without experimental intervention. However, written informed consent was obtained from the patient for participation and publication of anonymized clinical data in accordance with ethical standards for case reporting.

Results

This case report presents the clinical outcomes of a combined TENS and exercise intervention on pain intensity, muscle strength, and functional mobility in a patient with diabetic peripheral neuropathy over a three-week period. Measurements were conducted at baseline, week 2, and week 3 to capture short-term clinical changes following the intervention. To provide clinical context, the patient's baseline characteristics are summarized in Table 2.

Table 2. Patient Characteristics

Characteristic	Description
Initials	Mrs. S
Age	59 years
Sex	Female
Occupation	Housewife
Medical history	Diabetes mellitus
Clinical setting	UNS Hospital

Pain intensity was assessed at three time points using the Numeric Rating Scale (NRS) to evaluate changes in rest pain, tenderness, and movement-related pain. The results are presented in Table 3.

Table 3. Changes in Pain Intensity (NRS)

Pain Type	Baseline	Week 2	Week 3
Rest pain	1/10	0/10	0/10
Tenderness	6/10	5/10	4/10
Movement pain	5/10	4/10	3/10

Muscle strength of the lower extremities was evaluated using Manual Muscle Testing (MMT), focusing on key muscle groups at the knee and ankle joints. The progression of muscle strength over the intervention period is shown in Table 4.

Table 4. Changes in Muscle Strength (MMT)

Region	Baseline	Week 2	Week 3
Knee	3/5	3+/5	4/5
Ankle	3/5	3+/5	4/5

Functional mobility and dynamic balance were assessed using the Timed Up and Go Test (TUG). This measure was used to monitor changes in mobility performance across the intervention period. The results are presented in Table 5.

Table 5. Changes in Functional Mobility (TUG)

Time Point	TUG Score (seconds)
Baseline	20
Week 2	18
Week 3	16

To summarize the overall clinical progression across all outcome measures, a consolidated overview of changes is presented in Table 6. This table integrates key findings to illustrate the temporal pattern of improvement throughout the intervention period.

Table 6. Summary of Clinical Progression

Parameter	Baseline	Week 2	Week 3	Change (Baseline–Week 3)
Rest pain (NRS)	1/10	0/10	0/10	−1
Tenderness (NRS)	6/10	5/10	4/10	−2
Movement pain (NRS)	5/10	4/10	3/10	−2
Muscle strength (MMT)	3/5	3+/5	4/5	+1 grade
TUG (seconds)	20	18	16	−4 seconds

Across the three-week intervention period, consistent changes were observed in all measured outcomes. Pain intensity decreased across all conditions, muscle strength improved in both knee and ankle regions, and functional mobility demonstrated progressive improvement based on TUG performance. No adverse events were reported during the intervention period.

Discussion

This case report describes short-term improvements in pain intensity, muscle strength, and functional mobility following a combined intervention of Transcutaneous Electrical Nerve Stimulation (TENS) and therapeutic exercise in a patient with diabetic peripheral neuropathy (DPN). Although the findings are limited to a single case, the observed changes provide clinically relevant insights into the potential role of multimodal physiotherapy in managing DPN-related impairments.

The reduction in pain intensity observed in this case may be explained by the neurophysiological mechanisms underlying TENS.[18] Conventional TENS is widely associated with the gate control theory of pain, in which stimulation of large-diameter afferent fibers inhibits nociceptive transmission at the spinal cord level.[6,18] In addition, TENS has been reported to promote the release of endogenous opioids, thereby contributing to analgesic effects in neuropathic pain conditions.[6] These mechanisms are particularly relevant in DPN, where altered peripheral nerve signaling contributes to persistent pain.[18] Although the magnitude of pain reduction in this case was modest (Δ = −2), it aligns with clinically meaningful changes reported in neuropathic pain management.[18]

Beyond pain reduction, improvements in muscle strength were observed across the intervention period, as indicated by changes in MMT grading from 3/5 to 4/5. These findings are consistent with existing evidence demonstrating that structured exercise programs can enhance neuromuscular activation and motor unit recruitment in patients with DPN.[3] Strengthening exercises targeting distal lower extremity muscles are particularly important, as these muscles play a critical role in maintaining postural stability and gait efficiency.[7] The observed improvements may reflect neuromuscular adaptations resulting from repeated functional loading and motor practice, although the absence of objective strength measurement tools (e.g., dynamometry) limits the precision of this interpretation.

The improvement in functional mobility, as reflected by a reduction in TUG time from 20 to 16 seconds, suggests enhanced dynamic balance and walking ability. In clinical practice, TUG performance is strongly associated with fall risk, and reductions in completion time are generally interpreted as improved functional mobility.[6]Although minimal clinically important difference (MCID) values for TUG in DPN populations are not universally established, a reduction of approximately 3–4 seconds is often considered

clinically meaningful in populations with mobility impairments.[6] This indicates that the improvement observed in this case may have functional significance, particularly in reducing fall risk.

Importantly, the combined use of TENS and exercise may produce complementary or synergistic effects. While TENS primarily targets pain modulation, exercise therapy addresses neuromuscular and functional impairments.[9] Pain reduction may facilitate greater participation in exercise, thereby enhancing the effectiveness of rehabilitation. Conversely, improved muscle strength and balance may contribute to better functional outcomes beyond pain relief alone.[17] This interaction highlights the potential advantage of multimodal physiotherapy approaches in DPN management.[9] However, the extent to which each component contributed to the observed outcomes cannot be determined in this case due to the absence of a control condition.

When compared with previous studies, the findings of this case are generally consistent with reports indicating that exercise-based interventions improve balance and functional performance in patients with DPN.[19] Systematic reviews have demonstrated that interventions incorporating balance and strengthening exercises can enhance postural control and reduce fall risk.[19] However, evidence specifically examining the combined effects of TENS and exercise remains limited, and existing studies often show heterogeneity in intervention protocols and outcome measures.[6] This case therefore contributes to the literature by providing a detailed clinical description of a combined intervention applied in a real-world setting.

Despite these positive findings, several important limitations must be acknowledged. First, as a single-case report, the results cannot be generalized to broader populations. The absence of a control group also precludes causal inference, and improvements may be influenced by factors such as natural recovery, placebo effects, or increased patient attention during therapy. Second, the intervention duration was relatively short (three weeks), limiting the ability to assess long-term outcomes or sustainability of improvements. Third, the assessment of muscle strength relied on MMT, which has limited sensitivity in detecting subtle changes compared with quantitative measures. Fourth, the lack of standardized neuropathy severity assessment (e.g., DN4 or Michigan Neuropathy Screening Instrument) restricts the ability to contextualize the patient's baseline condition. Finally, incomplete clinical data, including glycemic control and duration of diabetes, further limits interpretability. In addition, patient-reported outcomes such as quality of life or functional perception were not assessed, limiting the understanding of subjective clinical benefit.

From a clinical perspective, this case highlights the potential value of integrating pain modulation and functional exercise in the management of DPN. A structured physiotherapy program combining TENS and targeted exercises may support improvements in pain, strength, and mobility, which are critical determinants of independence and fall prevention.[6,9] However, clinicians should interpret these findings cautiously and consider individual patient characteristics when designing treatment programs.

Future research should focus on well-designed randomized controlled trials to evaluate the effectiveness of combined TENS and exercise interventions in DPN populations. Standardization of intervention parameters, inclusion of objective outcome measures, and longer follow-up periods are essential to strengthen the evidence base and inform clinical practice.

Conclusion

This case report demonstrates that a combined intervention of Transcutaneous Electrical Nerve Stimulation (TENS) and therapeutic exercise was associated with short-term improvements in pain intensity, muscle strength, and functional mobility in a patient with diabetic peripheral neuropathy. These findings directly address the study objective, indicating that a multimodal physiotherapy approach may support functional recovery in this population.

From a clinical perspective, integrating pain modulation and structured exercise may facilitate improved participation in rehabilitation and enhance overall functional outcomes. However, the interpretation of these findings should be approached with caution due to the single-case design, short intervention duration, and absence of standardized neuropathy severity assessment.

Future studies are recommended to employ randomized controlled designs with larger sample sizes, standardized intervention protocols, and longer follow-up periods to confirm the effectiveness and generalizability of combined TENS and exercise interventions in patients with diabetic peripheral neuropathy.

Author Contribution

Chrisnami Ika Safira: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing Original Draft.
Umi Budi Rahayu: Supervision, Validation, Methodology, Writing Review and Editing.
Yunita Nur Rochmah: Data Interpretation, Validation, Writing Review and Editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This case report was conducted as part of routine clinical care and did not require formal ethical clearance. Written informed consent was obtained from the patient for participation and publication of anonymized clinical data, in accordance with ethical standards for case reporting.

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