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COMPARATIVE EFFICACY OF LOW-LEVEL LASER THERAPY AND TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION IN THE MANAGEMENT OF DIABETIC PERIPHERAL NEUROPATHY: A RANDOMIZED CONTROLLED TRIAL

Mohammadi E.[1]*, Nazarbaghi S.[2], Hajiesmaello M.[3]

[1]Department of Internal Medicine, School of Medicine, Urmia University of Medical Sciences, Urmia, Iran
[2]Department of Neurology, Imam Khomeini Hospital, Urmia University of Medical Sciences, Urmia, Iran
[3]Palliative Care Research Center, Ur.C., Islamic Azad University, Urmia, Iran

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Abstract

Introduction: *Diabetic peripheral neuropathy is a common and debilitating complication of diabetes, characterized by distal sensory loss, pain, and functional impairment. Conventional pharmacologic treatments often provide incomplete symptom relief and are associated with adverse effects, highlighting the need for effective adjunctive therapies. Low-level laser therapy and transcutaneous electrical nerve stimulation (TENS) have been proposed as non-pharmacologic options for diabetic peripheral neuropathy management. This study aimed to compare the efficacy of laser therapy and nerve stimulation, as adjuncts to standard pharmacologic therapy ,versus pharmacologic therapy alone in improving clinical symptoms and electrophysiological parameters in patients with diabetic peripheral neuropathy.*

Materials and Methods: *In this single-center, randomized controlled trial, 60 adult patients with confirmed DPN unresponsive to≤ 3 months of pharmacologic therapy were randomized into three groups :control) standard therapy, laser therapy and nerve stimulation) n=20 each. Interventions were delivered over 6 weeks, with 12 sessions for each therapy. Clinical assessments included sensory disturbance, pain and temperature sensation, and monofilament testing. Electrophysiological evaluations included nerve conduction studies) peroneal and tibial nerves (and H-reflex assessment. Ankle-brachial index was also measured. Statistical analysis included ANOVA ,paired t-tests, and non-parametric equivalents with significance set at p>0.05.*

Results: *Both laser therapyand nerve stimulation groups showed significant within-group improvement in clinical symptoms p>0.05. Post-intervention comparisons revealed that laser therapy significantly outperformed nerve stimulation and control in all clinical and electrophysiological measures) p>0.001. The proportion of patients with preserved sensation on monofilament testing was higher in the laser therapy group) 85% (versus nerve stimulation) 45% (and control) 60%) (p=0.026).*

Conclusion: *Low-level laser therapy also improved ankle-brachial index and nerve conduction parameters, including motor conduction velocity, latency ,compound muscle action potential amplitude, and H-reflex, whereas nerve stimulation showed only minimal or non-significant effects. No adverse events were reported. Laser therapy as an adjunct to standard pharmacologic therapy offers superior clinical and electrophysiological benefits compared to nerve stimulation or standard therapy alone in patients with diabetic peripheral neuropathy suggesting potential functional nerve recovery. nerve stimulation may represent a promising therapeutic strategy to improve quality of life in diabetic peripheral neuropathy.*

Keywords: *Diabetic peripheral neuropathy, low-level laser therapy, TENS, randomized controlled trial, electrophysiology, nerve conduction, pain management*

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Address for Correspondence:
Ebrahim Mohammadi; M.D.;
Department of Internal Medicine, School of Medicine,
Urmia University of Medical Sciences, Resalat Blvd, Jahad
Ave , Urmia, 57147-83734, Iran
Tel.: +984432237082
Email: pharmabiology2021@gmail.com

INTRODUCTION

Diabetic peripheral neuropathy is a prevalent and debilitating complication of diabetes mellitus, affecting a significant proportion of individuals with either type 1 or type 2 diabetes [*Loscalzo J et al 2022*]. Chronic hyperglycemia and associated metabolic disturbances drive progressive peripheral nerve damage, predominantly affecting sensory and motor fibers in a length-dependent manner. Consequently, clinical manifestations typically arise first in distal extremities, such as the feet and hands [*Rutkove S et al., 2024*].

Diabetic peripheral neuropathy presents a heterogeneous spectrum of symptoms, including neuropathic pain commonly described as burning, shooting,.or electric shock-like sensations paresthesia (tingling or “pins and needles), dysesthesia, altered temperature and tactile perception, and progressive deficits in vibratory and proprioceptive sensation [*Loscalzo J et al; 2022; Rutkove S et al, 2024*]. Advanced stages often involve motor nerve impairment, resulting in muscle weakness, atrophy, gait disturbances, and a heightened risk of foot ulcers and amputation due to impaired sensory and motor function [*Loscalzo J et al, 2022; Rutkove SB et al., 2024*]. Collectively, these manifestations substantially compromise functional capacity, psychological well-being, and overall quality of life, imposing a considerable burden on patients, caregivers, and healthcare systems worldwide.

Current management of Diabetic peripheral neuropathy emphasizes optimal glycemic control to slow nerve injury, alongside symptomatic treatment of neuropathic pain and sensory dysfunction. Pharmacologic strategies typically include anticonvulsants (e.g., gabapentin, pregabalin), antidepressants including serotonin-norepinephrine reuptake inhibitors (duloxetine, venlafaxine) and tricyclic antidepressants and topical agents (e.g., capsaicin, lidocaine). Despite providing partial symptom relief, these agents often fail to achieve adequate control in many patients and are frequently associated with adverse effects such as somnolence, dizziness, cognitive disturbances, gastrointestinal upset, and weight gain, which can limit adherence and further compromise quality of life [*Galiero R et al., 2023; Price R et al., 2022*]. This underscores the critical need for safe, effective, and well-tolerated alternative or adjunctive therapeutic approaches [*Price R et al., 2022*].

Non-pharmacological interventions have recently gained attention as complementary strategies for Diabetic peripheral neuropathy management [*Riker DK, 2010; Anju M et al., 2019*]. Among these, low-level laser therap, or photobiomodulation therapy, and transcutaneous electrical nerve stimulation have emerged as promising modalities [*Smith S et al., 2024*]. Low-level laser therapy delivers low-intensity laser or light-emitting diode irradiation to target tissues, promoting cellular repair, modulating inflammation, alleviating pain, and potentially enhancing nerve regeneration through mechanisms including increased adenosine triphosphate (ATP) production, modulation of reactive oxygen species, and nitric oxide release [*Bashiri H, 2013; Lin L et al., 2021*]. In contrast, Electrical nerve stimulation applies low-voltage electrical currents via skin electrodes to modulate pain perception by stimulating sensory fibers and activating descending inhibitory pathways, including gate control mechanisms and endogenous opioid release [*Naderi Nabi B et al., 2021*]. Although both interventions have shown benefits in chronic pain and neuropathic conditions, direct comparative evidence-particularly as adjuncts to standard pharmacologic therapy in DPN is limited and often derived from small or methodologically heterogeneous studies. Low-level laser therapy enhances local blood circulation and stimulates tissue repair, helping improve diabetic neuropathy and reduce pain. This non-invasive approach has minimal side effects and is recommended as an adjunct therapy alongside conventional diabetes management [*Kazemi-Khoo N, 2006; Beckmann KH et al., 2014; Mathur R et al., 2017; Olejnik M et al., 2019; Santos C et al., 2021*].

To address this gap, we designed a randomized controlled trial to compare the efficacy of Laser therapyv and Electrical nerve stimulation, in addition to conventional pharmacologic therapy, versus standard therapy alone, in patients with Diabetic peripheral neuropathy refractory to conventional treatment. By evaluating both clinical symptoms and objective electrophysiological parameters, this study aims to generate rigorous evidence on the comparative effectiveness of these non-pharmacological interventions, providing guidance for optimizing Diabetic peripheral neuropathy manage-

ment in a challenging patient population.

Materials And Methods

Study Design and Participants: This prospective, single-center, randomized controlled trial was conducted at Imam Khomeini Hospital, a tertiary care center affiliated with Urmia University of Medical Sciences, Urmia, Iran, in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. The study protocol received ethical approval from the Research Ethics Committee of Urmia University of Medical Sciences (Approval No. IR.UMSU.REC.1403.274) prior to initiation.

Inclusion Criteria: Adult patients (≥18 years) with a confirmed diagnosis of type 1 or type 2 diabetes mellitus according to American Diabetes criteria, and clinically and electrophysiologically confirmed diabetic peripheral neuropathy of the lower extremities, were eligible. Additional criteria included: diabetes duration greater than or equal 5 years, inadequate response to at least 3 months of standard pharmacologic treatment for neuropathic pain (e.g., gabapentin, pregabalin, duloxetine, venlafaxine, tricyclic antidepressants), defined as persistent moderate-to-severe neuropathic symptoms (Numeric rating scale greater than or equal 4/10 or significant sensory deficits), and provision of written informed consent.

Exclusion Criteria: Participants were excluded for: other causes of neuropathy (e.g., vitamin B12 deficiency, thyroid dysfunction, autoimmune or hereditary neuropathies), significant lower limb orthopedic or vascular conditions (e.g., advanced peripheral artery disease, recent trauma, active foot ulcers, Charcot joint), central neurological disorders (e.g., stroke, spinal cord injury), implanted electronic devices (e.g., pacemakers, defibrillators), pregnancy or lactation, severe cognitive impairment, or prior exposure to Laser therapyv or Electrical nerve stimulation within 6 months.

Of 85 patients screened, 25 were excluded, resulting in 60 eligible participants randomized into three groups.

Randomization and Interventions: Participants were randomly allocated in a 1:1:1 ratio using a computer-generated sequence, with block randomization to ensure balanced group sizes. An independent researcher, not involved in patient assessment or treatment, performed the allocation to maintain blinding of outcome assessors and treating clinicians where feasible.

Intervention Groups:

Control Group (n=20): Continued standard pharmacologic management for Diabetic peripheral neuropathy without additional physical therapy interventions.

***Low-Level Laser Group (n=20)*:** Received standard pharmacologic therapy plus low-level laser therapy using the Icoone Laser Med device (Italy, 2022). Twelve sessions were administered twice weekly over six weeks, each lasting ~30 minutes. The laser was applied to affected lower limbs, targeting areas of maximal sensory deficit and pain. Parameters - including wavelength (905 nm near-infrared, 650 *nm* visible red), power output, and energy density (J/cm^2) - were standardized according to manufacturer guidelines and previous literature to ensure therapeutic dosing without thermal injury.

Transcutaneous electrical nerve stimulation Group (n=20): Received standard pharmacologic therapy plus transcutaneous electrical nerve stimulation using a digital Electrical nerve stimulation unit. Twelve sessions were delivered twice weekly over six weeks, each lasting ~15 minutes. Electrodes were positioned over major lower limb nerves (peroneal, tibial, and sciatic pathways). A modulated Electrical nerve stimulation mode with standardized frequency, pulse width, and intensity was applied at a comfortable, non-painful sensory threshold.

All participants were instructed to maintain routine diabetes management and daily activities throughout the study.

Outcomes Assessments were conducted at baseline and after the 6-week intervention period.

Primary Outcomes

Clinical Neurological Examination: Trained neurologists blinded to group allocation assessed sensory disturbances using standardized scales for numbness, tingling, burning, and pain/temperature perception (0–10 scale).

Semmes-Weinstein Monofilament Test: Light touch and pressure sensation were evaluated at multiple foot sites using a 10*g* monofilament. The number of correctly detected sites indicated preserved protective sensation.

Secondary Outcomes

Ankle-Brachial Index: Measured using a handheld sphygmomanometer; ankle-brachial index greater than or equal 0.9 indicated normal peripheral perfusion.

Electrophysiological Assessment: Standard electromyography and nerve conduction velocity studies of the peroneal and tibial nerves recorded motor conduction velocity, distal latency, compound muscle action potential amplitude, and soleus H-reflex amplitude and latency.

Adverse Events: Participants were monitored for adverse events, including skin reactions or worsening symptoms, throughout the study. All events were documented, graded, and evaluated for relation to the interventions.

Statistical Analysis: Data were analyzed using SPSS version 26.0. Normally distributed continuous variables are presented as mean ± SD; non-normal data as median (IQR); categorical variables as counts and percentages. Baseline comparisons employed ANOVA or Kruskal-Wallis tests for continuous variables, and Chi-square or Fisher's exact tests for categorical variables. Within-group changes were assessed using paired t-tests or Wilcoxon signed-rank tests. Between-group differences post-intervention were analyzed with ANOVA (Tukey's HSD post-hoc) or Kruskal-Wallis tests as appropriate. Categorical outcomes were compared using Chi-square or Fisher's exact test. Statistical significance was set at $p<0.05$ (two-sided).

Results

Comparison of Demographic Characteristics Among Patients with Diabetic Neuropathy Across Three Groups

A total of 60 patients with diabetic neuropathy were included in the analysis, with 20 participants allocated to each group. A significant difference in gender distribution was observed among the groups, with the majority of patients being female in both the laser therapy group (90%) and the Electrical nerve stimulation group (70%) ($p = 0.048$). However, no significant difference in mean age was detected among the groups ($p = 0.175$).

The demographic characteristics of the patients, including gender and age, are summarized in Table 1. The mean age of patients was 55.95± 9.04 years in the laser therapy group 12.91±61.95, years in the Electrical nerve stimulation group, and 7.21±58.85 years in the control group, with no significant differences observed between the groups ($p=0.175$). Therefore, the groups were comparable in terms of age.

Before intervention, mean scores for sensory impairment (including paresthesia and anesthesia) were uniform across all groups, with every patient scoring 10. Following treatment, sensory impairment was significantly reduced in the laser therapy group compared to the Electrical nerve stimulation and control groups. Post-treatment means sensory impairment scores were 1.6±3.95 for the laser therapy group 9.05±0.76, for the Electrical nerve stimulation group, and unchanged at 10 for the control group ($p<0.001$.(Pairwise comparisons revealed significant differences between laser therapy versus Electrical nerve stimulation and laser therapy versus control ($p<0.001$), but no significant difference between Electrical nerve stimulation and control ($p=0.129$).

Similarly, post-treatment pain-temperature perception impairment significantly decreased in the laser therapy group compared to the Electrical nerve stimulation and control groups. Mean scores post-treatment was 3.9±1.68 for laser therapy 3.9±0.86, for Electrical nerve stimulation, and unchanged at 10 for the control group ($p<0.001$). Pairwise comparisons mirrored those of sensory impairment. Within-group analysis demonstrated significant improvements in both sensory and pain-temperature perception in the laser therapy group (<0.001) and in the Electrical nerve stimulation group ($p<0.05$), while the control group remained unchanged (Table 2).

Prior to treatment, no significant difference in monofilament sensory impairment was observed among groups ($p=0.098$). Post-treatment, the prevalence of impairment differed significantly: 85% of patients in the laser therapy group, 45% in the Electrical nerve stimulation group, and 60% in the control group tested negative for monofilament deficits. In the Electrical nerve stimulation and control groups 3-2 points of impairment were detected, while no such deficits were observed in the laser therapy group. Bonferroni-adjusted pairwise comparisons confirmed significant differences between laser therapy and both Electrical nerve stimulation and control, with no significant dif-

Table 1.

Comparison of Demographic Characteristics Among Patients with Diabetic Neuropathy

Variable	Grousps			P-value
	Laser Therapy n=20	TENS n=20	Control n=20	
Age (years)	55.95±9.0	61.9±12.9	58.9±7.2	0.17
Gender,				
Male n (%)	2 (10%)	6 (30%)	9 (45%)	
Female n(%)	18 (90%)	14 (70%)	11 (55%)	

Table 2.

Comparison of Sensory and Pain-Temperature Perception Impairments (One-way ANOVA; Paired t-test for within-group comparisons)

Variable	Before	After
Sensory Impairment		
Laser Therapy	10 ± 0.001	3.95 ± 1.6
TENS	10 ± 0.001	9.05 ± 0.76
Control	10 ± 0.001	10 ± 0.001
Pain-Temperature Impairment		
Laser Therapy	10 ± 0.001	3.9 ± 1.68
TENS	10 ± 0.001	3.9 ± 0.86
Control	10 ± 0.001	10 ± 0.001

Table 3.

Monofilament Sensory Impairment Prevalence (Fisher's exact test.)

Monofilament Impairment	Laser Therapy	TENS	Control
Before			
Negative, n (%)	15 (75%)	9 (45%)	11 (55%)
1 point, n (%)	4 (20%)	8 (40%)	4 (20%)
2 points, n (%)	1 (5%)	1 (5%)	5 (25%)
3 points, n (%)	0	2 (10%)	0
After, n (%)			
Negative, n (%)	17 (85%)	9 (45%)	12 (60%)
1 point, n (%)	3 (15%)	8 (40%)	4 (20%)
2 points, n (%)	0	1 (5%)	4 (20%)
3 points, n (%)	0	2 (10%)	0

Table 4.

Ankle-Brachial Index Comparison (One-way ANOVA Test)

Variable	Before	After
Laser Therapy	1.04 ± 0.1	1.06 ± 0.1
TENS	0.82 ± 0.04	0.82 ± 0.04
Control	0.86 ± 0.03	0.86 ± 0.03
P-value	0.042	0.023

ference between Electrical nerve stimulation and control (table3)

Other physical findings showed that all patients tested negative for position sense deficits both pre- and post-intervention. Patellar reflex abnormalities were observed in only one Electrical nerve stimulation patient, and Achilles reflex abnormalities in two Electrical nerve stimulation patients, with no significant differences across groups ($p<0.05$).

Ankle-brachial index was consistently higher in the laser therapy group, both pre- and post-treatment, compared to Electrical nerve stimulation and control groups, indicating significant differences ($p<0.05$) (table 4).

Significant differences in all electromyography and nerve conduction velocity parameters were observed among the groups. The peroneal nerve conduction velocity increased post-intervention in the laser therapy group (mean change (3.06±0.62) while it decreased in the Electrical nerve stimulation (-0.25±0.06) and control groups (-1.35±0.74) ($p<0.001$. Similarly, tibial nerve conduction velocity increased in laser therapy (3.1±0.71) and decreased in Electrical nerve stimulation (-1.1±0.58) and control (-1.12±0.06) ($p<0.001$).

Reductions in peroneal and tibial motor latency were observed in the laser therapy group, in contrast to slight increases or decreases in Electrical nerve stimulation and control groups, with all intergroup differences significant (p,0.001). Increases in peroneal and tibial motor amplitudes were significantly higher in the laser therapy group compared to minimal changes in Electrical nerve stimulation and control groups. Within-group comparisons confirmed significant improvements in all electromyography and nerve conduction velocity parameters in the laser therapy group, limited improvements in Electrical nerve stimulation, and deterioration in the control group ($p<0.05$) (table 5).

In the laser therapy group, 18 patients initially exhibited no H-reflex response; post-treatment, this decreased to 15 patients. No change was observed in Electrical nerve stimulation or control groups. Bonferroni-adjusted comparisons revealed significant differences between laser therapy and the other groups, but not between Electrical nerve stimulation and control ($p=0.007$) (table 6).

Among responders, post-treatment changes in H-reflex differed significantly across groups. The

TABLE 5.

Comparison of EMG/NCV Parameters Among Patients with Diabetic Neuropathy

Variable	Laser Therapy (n=20)	TENS (n=20)	Control (n=20)	P-value
Peroneal Nerve Conduction Velocity (m/s)				
Before	35.30 ± 9.53	41.05 ± 6.25	31.55 ± 13.89	0.012
After	38.36 ± 10.35	40.45 ± 5.84	30.20 ± 13.65	0.005
Within-group change	3.06 ± 0.62	-0.25 ± 0.6	-1.74 ± 0.35	<0.001
p-value	0.001	0.09	0.03	-
Tibial Nerve Conduction Velocity (m/s)				
Before	36.22 ± 10.18	41.20 ± 4.67	31.35 ± 13.63	0.007
After	39.32 ± 10.75	40.21 ± 5.40	30.63 ± 13.22	0.008
Within-group change	3.71 ± 1.0	-1.58 ± 0.1	-1.12 ± 0.06	<0.001
p-value	0.001	0.04	0.04	-
Peroneal Motor Latency (ms)				
Before	8.07 ± 3.10	6.32 ± 1.28	6.11 ± 2.58	0.003
After	7.33 ± 2.67	6.38 ± 1.18	6.41 ± 2.67	0.95
Within-group change	-0.74 ± 0.19	0.06 ± 0.05	0.3 ± 0.12	<0.001
p-value	0.001	0.21	0.004	-
Tibial Motor Latency (ms)				
Before	8.04 ± 2.74	5.96 ± 1.09	5.92 ± 2.32	<0.001
After	6.92 ± 2.04	5.85 ± 1.09	6.24 ± 2.45	0.013
Within-group change	-1.11 ± 0.25	-0.11 ± 0.04	0.32 ± 0.11	<0.001
p-value	0.001	0.02	0.004	-
Peroneal Motor Amplitude (mV)				
Before	0.96 ± 0.77	2.79 ± 1.23	1.20 ± 0.94	<0.001
After	1.12 ± 0.78	2.81 ± 1.21	1.21 ± 0.99	0.001
Within-group change	0.15 ± 0.04	0.02 ± 0.03	0.005 ± 0.03	0.007
p-value	0.002	0.47	0.89	-
Tibial Motor Amplitude (mV)				
Before	1.12 ± 1.1	2.65 ± 1.18	0.84 ± 0.66	<0.001
After	1.31 ± 1.07	2.7 ± 1.21	0.79 ± 0.73	0.001
Within-group change	0.18 ± 0.05	0.05 ± 0.03	-0.05 ± 0.04	0.002
p-value	0.004	0.27	0.18	-

TABLE 6.

H-Reflex Prevalence (Chi-square test)

Variable	Response		Not response	
H-Reflex	Before	After	Before	After
Laser Therapy	2 (10%)	5 (25%)	18 (90%)	15 (75%)
TENS	11 (55%)	11 (55%)	9 (45%)	9 (45%)
Control	2 (10%)	2 (10%)	18 (90%)	18 (60%)

TABLE 7.

Mean H-Reflex comparison (responders). Paired t-test for within-group changes (One-way ANOVA Test)

Variable	Before	After	Within changes
Laser therapy	39.5±0.71	34.1±1.41	-5.71±0.71
TENS	36.0±0.4	36.09±0.4	0.09±0.04
Control	40.6±0.71	40.07±0.71	-3.71±0.71
P-value	0.35	0.2	<0.001

laser therapy group showed a mean reduction of -5.71± 0.71whereas Electrical nerve stimulation exhibited a slight increase (0.09±0.04) and control showed a smaller reduction (-3.71±0.71) ($p<0.001$). Within-group analysis confirmed significant reductions only in the laser therapy group ($p=0.05$) with no significant changes in Electrical nerve stimulation or control (table 7).

DISCUSSION

This randomized controlled trial evaluated the comparative efficacy of low-level laser therapy and transcutaneous electrical nerve stimulation (Electrical nerve stimulation) as adjuncts to standard pharmacologic therapy in patients with treatment-refractory diabetic peripheral neuropathy. Our results demonstrate that Laser therapyv produces significant and clinically meaningful improvements in both patient-reported symptoms and objective electrophysiological measures of nerve function, outperforming both Electrical nerve stimulation and standard therapy alone. These findings corroborate and extend prior evidence supporting the therapeutic potential of photobiomodulation in neuropathic conditions [*Bashiri H, 2013*]. The Laser therapyv group exhibited marked reductions in sensory disturbance and pain/temperature loss scores, along with significant improvements on the Semmes-Weinstein monofilament test, indicating a direct restorative effect on sensory deficits characteristic of Diabetic peripheral neuropathy. Objective electrophysiological parameters including motor conduction velocity, distal latency, compound muscle action potential amplitude, and H-reflex demonstrated substantial improvement, suggesting functional recovery or regeneration of peripheral nerve fibers, which is rarely achieved with pharmacotherapy alone. The observed enhancements in nerve conduction and H-reflex parameters likely reflect Laser therapyv-mediated mechanisms such as increased ATP production, reduced oxidative stress, modulation of inflammation, improved microcirculation, and potential stimulation of axonal

growth and myelin repair [*Bashiri H, 2013; Lim, 2021*]. Although the Electrical nerve stimulation group experienced modest symptomatic relief relative to baseline, these improvements were significantly less pronounced than those observed with Laser therapyv. Importantly, Electrical nerve stimulation did not induce significant changes in electrophysiological measures or monofilament test outcomes, implying that its effect is primarily symptomatic via neuromodulation rather than promoting underlying nerve repair. These findings align with previous studies reporting limited impact of Electrical nerve stimulation on nerve conduction parameters despite some analgesic benefit [*Bashiri H, 2013*]. The absence of meaningful improvement in the control group underscores the limitations of standard pharmacologic therapy in refractory Diabetic peripheral neuropathy, highlighting the need for adjunctive or alternative therapeutic strategies [*Naderi N et al., 2015*]. Notably, the improvement in ankle-brachial index observed in the Laser therapyv group, although secondary, suggests enhanced peripheral microcirculation, which may further support nerve health and contribute to the overall therapeutic benefit. Strengths of this study include its rigorous randomized controlled trial design, inclusion of both subjective and objective outcome measures, and the focus on a well-defined, treatment-refractory patient population [*Cg S et al.,2015*]. Comprehensive electrophysiological assessments strengthen the validity of the findings. Additionally, no adverse events were reported, indicating a favorable safety profile for both Laser therapyv and Electrical nerve stimulation when applied appropriately. In the systematic review integrates the existing evidence on the efficacy and safety of Laser therapyv in patients with diabetic peripheral neuropathy and provides a detailed comparison with sham, no treatment, and conventional therapies [*Lin L, 2021*]. Low-level laser therapy, with the parameters applied, significantly reduced pain and improved neurovascular function in patients with diabetic peripheral neuropathy, suggesting its potential as an effective therapeutic approach [*Yamany A, Sayed H, 2012*]. Electrical stimulation and Electrical nerve stimulation may serve as safe and effective non-pharmacological treatments for alleviating diabetic neuropathy symptoms, whereas the efficacy of low-level laser therapy remains uncertain due to variations in parameters and limited studies, highlighting the need for further randomized controlled trials [*Adehunoluwa EA et al., 2019*]. The results of one study indicated that evidence suggests low-level laser therapy has a positive effect on controlling pain in diabetic neuropath [*Anju M et al., 2019*].

Limitations include the relatively short six-week intervention period, which may not capture long-term effects. Gender imbalance, with a higher proportion of females in the Laser therapyv and Electrical nerve stimulation groups, could potentially influence outcomes, although the magnitude of Laser therapyv's effect likely exceeds what could be attributed to this difference. Complete blinding of participants and therapists was not feasible due to the nature of the interventions; future studies might incorporate sham controls to mitigate this limitation. Finally, the single-center design may limit generalizability. Overall, the robust and consistent efficacy demonstrated by Laser therapyv supports its consideration as a valuable adjunctive therapy for Diabetic peripheral neuropathy, offering not only symptomatic relief but also objective improvements in nerve function.

Conclusion

In patients with refractory diabetic peripheral neuropathy, Laser therapyv as an adjunct to standard pharmacologic therapy significantly outperforms Electrical nerve stimulation and standard therapy alone in improving clinical symptoms, sensory function, and electrophysiological nerve parameters. The observed improvements in nerve conduction and sensory perception suggest potential nerve regeneration or functional recovery. With its strong efficacy and favorable safety profile, Laser therapyv represents a promising adjunctive modality for comprehensive diabetic peripheral neuropathy management. Further multi-center trials with longer follow-up are warranted to confirm these findings and optimize treatment protocols.

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Armen A. ***Muradyan***

Address for correspondence:

Yerevan State Medical University
2 Koryun Street, Yerevan 0025,
Republic of Armenia

Phones:

(+37410) 582532 YSMU
(+37493) 588697 Editor-in-Chief
Fax: (+37410) 582532
E-mail:namj.ysmu@gmail.com, ysmiu@mail.ru
URL:http//www.ysmu.am

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Yerevan, 0064, Armenia
Phone: (+37491) 40 25 86
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