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Research Article

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Efficacy of Neuromodulation Therapy for Neuropathy Symptom Reduction and Functional Improvement

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Abstract

Background/Objectives: *Targeted neuromodulation therapies are increasingly used for the management of peripheral neuropathy; however, data on symptom and functional outcomes following standardized treatment courses remain limited. This report evaluates the efficacy of NeoGen Neuromodulation treatments administered at the National Neuropathy Center, focusing on changes in sensory symptoms and functional task performance from the first treatment (T1) to the twelfth treatment (T12) over a mean treatment duration of 36 sessions.*

Methods: *Patients completing a standardized 12-treatment course using the NeoGen Neuromodulation device were analyzed. Outcomes included patient-reported sensory symptoms (tingling, numbness, and pain) and measures of functional task performance. Changes from baseline (T1) to post-treatment (T12) were assessed to determine treatment effectiveness, response patterns, and areas for clinical optimization.*

Results: *Patients demonstrated clear and measurable benefits following completion of 12 treatments. The greatest improvements were observed in sensory symptoms, with tingling, numbness, and pain each improving by approximately one point on the severity scale. Over half of patients achieved clinically meaningful relief in these sensory domains. Functional improvement was more modest, with meaningful gains observed in approximately one-quarter to one-third of patients. Non-response rates were low, although residual symptoms and functional limitations remained common.*

Conclusions: *The standard NeoGen Neuromodulation treatment protocol provides substantial relief of sensory neuropathic symptoms, with consistent benefits across patients. While functional gains were less pronounced, the low non-response rate supports overall treatment effectiveness. Persistent symptoms in some patients suggest a potential role for maintenance therapy and adjunctive interventions to optimize long-term outcomes.*

Keywords: Peripheral Neuropathy, Neuromodulation, Peripheral Nerve Stimulation, Neuropathic Pain, National Neuropathy Center, Neogen Neuromodulation Device

Abbreviations

The following abbreviations are used in this manuscript:

TENS	Transcutaneous electrical nerve stimulation
PNS	Peripheral nerve stimulation
NLP	Natural language processing
HPI	History of present illness
SNRIs	Serotonin-norepinephrine reuptake inhibitors
TCAs	Tricycle antidepressants
RFA	Radiofrequency ablation

1. Introduction

1.1. Background

Neuropathy is a debilitating condition characterized by chronic pain, numbness, tingling, burning sensations, and muscular weakness, all of which can significantly impair quality of life. Neuropathy can stem from various causes, including diabetes, infections such as varicella and HIV, autoimmune diseases such as lupus and rheumatoid arthritis, trauma, medications, vitamin deficiencies, and inherited disorders. Regardless of the underlying cause, neuropathies are often progressive and can affect motor, sensory, and autonomic fibers [1]. While the exact pathophysiology of neuropathy depends on the underlying condition, there are three mechanisms by which peripheral nerves can be injured. Segmental demyelination refers to degeneration of the myelin sheath surrounding axons [2]. The breakdown of myelin typically occurs in segments along the nerve, and the axon is spared. However, signal transduction is often disrupted or lost, as axons depend on the myelin sheath for saltatory conduction and increased action potential firing. A classic example of segmental demyelination is Charcot-Marie-Tooth disease. Another mechanism, known as Wallerian degeneration, occurs when an axon is separated from its cell body, often after nerve severing or compression. The distal fragment of the axon degenerates due to nutrient and cell-signaling deficiencies, triggering apoptosis, and the remnants are cleared by macrophages [3]. Finally, axonal degeneration, also known as dying-back degeneration, occurs when degeneration of an axon starts distally and extends proximally towards the cell body. The distal portion of the axon is vulnerable because its greater distance from the cell body often leads to decreased metabolic support and reduced delivery of survival factors [4]. This type of degeneration is more common in disorders such as diabetes, HIV, hepatitis C virus, and Guillain-Barré syndrome. Furthermore, understanding the underlying causes of neuropathy can help determine its pathophysiology and guide treatment [5].

Standard treatment approaches are typically symptom-focused, offering temporary relief without directly addressing the underlying neurophysiological dysfunction. Initial treatment options include pain medications such as gabapentin, pregabalin, duloxetine, or amitriptyline, as well as topical options such as lidocaine or capsaicin, lifestyle changes (diet, exercise, no smoking), and physical therapy for nerve health and function [6]. Other recommendations include addressing the underlying cause, such as maintaining strict glucose control, alcohol cessation, supplementation of nutrients and vitamins, and clearing infections. Procedural techniques are also an option, including nerve blocks, spinal cord stimulators, transcutaneous electrical nerve stimulation (TENS), and nerve decompression surgeries. Still, the risks and benefits need to be thoroughly discussed with patients before proceeding [7]. For patients experiencing refractory neuropathy, a standardized protocol and treatment plan that provides sustained relief is necessary. The National Neuropathy Center utilizes targeted neuromodulation therapy to improve peripheral nerve function and local blood flow. This therapeutic approach aims to reduce, and in some cases eliminate, neuropathic symptoms such as numbness, tingling, burning, and tightness. In addition to symptom relief, reported functional improvements have included increased ease with daily activities such as bending or stooping, putting on shoes, sleeping, standing for extended periods, climbing stairs, walking through stores, driving, meal preparation, yard work, and retrieving items from the floor. Peripheral nerve stimulation (PNS) involves delivering electrical impulses to peripheral nerves via implanted electrodes attached to a generator. Electrical stimulation disrupts nociceptive signals by blocking afferent Aδ and C fibers and acts directly on the nervous system, thereby avoiding systemic effects [8]. Additionally, increased local prostaglandin release in chronic pain increases blood flow to the affected area. Still, PNS has been shown to decrease levels of neurotransmitters and markers of inflammation, thereby reducing the transmission of pain signals [9,10]. A central mechanism of action for PNS has been proposed based on the observation that analgesia is typically achieved at stimulation intensities perceptible to the patient but below the nociceptive threshold, suggesting modulation of central sensory processing rather than direct peripheral nerve blockade [11]. Finally, PNS may decrease ectopic signaling and the rate of Wallerian degeneration [12]. The use of PNS is indicated for chronic pain refractory to conventional therapies. Additionally, temporary PNS can be used for up to 60 days for acute post-surgical pain [13]. While surgical PNS implantation was initially done with surgical dissection to visualize nerves, it is carried out via a percutaneous approach under ultrasound or fluoroscopy guidance [14]. For this procedure, a small electrode is inserted near a specific nerve, and after a positive trial phase, a generator is placed subcutaneously [15]. However, wireless peripheral nerve stimulators are also available, easier to implant, and require fewer leads and wires than traditional systems [16]. Furthermore, several studies have demonstrated the effectiveness of PNS, with at least 50% of patients reporting sustained pain relief [17-21]. However, this study uses a specific 12-treatment protocol to assess the longevity of NeoGen PNS. NeoGen PNS Neuromodulation uses various frequencies in conjunction with electrical stimulation to increase mitochondrial ATP production and enhance cellular regeneration via mitosis. NeoGen neuromodulation can therefore regenerate small nerve and microvascular tissue, offering healing for the patient rather than just symptom relief.

1.2. Treatment Protocol

Participation in this treatment protocol requires a diagnosis of peripheral neuropathy (either diabetic or idiopathic). Patients are typically treated in 12-visit increments (3 times per week over 1 month), with formal re-evaluation after each treatment cycle. Depending on individual response, some patients complete their treatment after 12 sessions, while others may continue for 24, 36, 48 sessions, or more (M=36). Treatment is concluded when both subjective symptom reports and objective clinical measures indicate resolution or significant improvement. For patients who achieve meaningful recovery but wish to maintain progress, a maintenance schedule may be recommended, ranging from 1-2 sessions per month to as few as 1-2 sessions per year. All plans of care are individualized and determined by patient-specific outcomes.

1.3. Objective

This clinical review aims to evaluate the effectiveness and practical implications of targeted neuromodulation therapy in a real-world outpatient setting. Specific goals include 1) assessing treatment efficacy across neuropathic and musculoskeletal symptoms using patient-reported outcomes and objective clinical indicators and 2) providing data-driven insights into clinical outcomes and functional quality-of-life improvements for use by healthcare stakeholders.

1.4. Relevance to Insurers and Healthcare Providers

The use of the PNS NeoGen device for chronic pain is relevant to insurers and healthcare providers for three main reasons. First, PNS NeoGen is cost-efficient in that sustained symptom reduction may reduce the frequency of emergency visits, specialist consultations, imaging procedures, and long-term pharmacological management. Second, patient satisfaction levels are high with consistently high response rates supporting the use of non-invasive, neuromodulatory interventions as a viable first-line or adjunct therapy. Third, PNS NeoGen can be used as a chronic care strategy, as findings support ongoing maintenance care for select patients with chronic or recurrent symptoms, aligning with value-based care models that prioritize long-term outcomes and patient-centered care.

2. Materials and Methods

All data were securely handled in compliance with HIPAA regulations to ensure patient privacy and confidentiality. All analyses and findings are based on these securely managed records.

2.1. Data Overview

This analysis is based on 2,682,779 clinical note entries collected from patients treated at the National Neuropathy Center between March 8, 2019, and December 31, 2025. Each entry contains structured and semi-structured data, including patient demographics, visit dates, note types, physician-entered content, and symptom reports. The dataset includes fields such as PATIENTS_ID, DATE_OF_VISIT, NOTE_TYPE, NOTESECTIONTYPE, and a rich free-text DATA field capturing patient-reported outcomes, clinical assessments, and treatment documentation. Listed below is an example data field entry for a typical patient encounter.

Example Data Field Entry

Time Spent with Patient: 30 minutes (25 minutes face-to-face)
Treatment Number: 4
Placement of Electrodes: Bilateral ankles and toes
Symptom Intensity (0–10 Scale): Pain: 0, Numbness: 2, Tingling: 0, Burning: 0,
Tightness: 3 Functional Limitation Ratings (1–5 Scale):
Bending or Stooping: 2
Putting on Shoes: 3
Sleeping: 3
Standing Up for an Hour: 3
Going Up or Down a Flight of Stairs: 3
Walking Through a Store: 3
Driving for an Hour: 0
Preparing a Meal: 3
Yard Work: 0
Picking Up Items from the Floor: 2
Patient Changes Since Last Treatment: Feeling a little better in feet
Patient Changes Since Start of Treatment: Improvement
Recent Functional Issues or Achievements (past 3 days): Good

2.2. Data Processing for Clinical Analysis

The raw dataset was curated through a multi-stage validation, extraction, and subsetting pipeline. The dataset structure was initially validated in consultation with clinical collaborators. A representative sample was manually confirmed for relevance and internal consistency. Using R, the dataset was filtered to retain only records containing structured symptom severity and functional limitation information. Key variables extracted from the DATA field included treatment number, treatment program, and numeric ratings for symptoms (pain, numbness, tingling, burning, or tightness on a 0–10 scale) and for functional limitations (sleeping, putting on shoes, or yard work on a 1–5 scale). Regular expressions and conditional logic were implemented to standardize the extracted values and resolve inconsistent formatting. Records related to intake evaluations or initial history of present illness (HPI) visits were excluded to isolate active treatment sessions. Manual treatment count inconsistencies were resolved by reconstructing each patient's visit sequence using treatment numbers and the chronological order of visit dates. This enabled a valid analysis of treatment response trajectories.

2.3. Exclusion Criteria

To avoid misclassification due to incomplete data at the edge of the dataset collection window, patients with their last visit after April 1, 2025, and fewer than 24 treatments were excluded to avoid including in-progress cases.

3. Results

This study consisted of 77,969 treatment-specific records from 3,588 unique patients.

3.1. Data Completeness

Completeness varied across variables, with most symptom and

function measures recorded for roughly two-thirds of visits. The percentage of non-missing (complete) data for key variables was as follows: 74.51% of visits assessed pain, 68.48% of visit assessed numbness, 67.48% of visits assessed tingling, 68.00% of visits assessed burning, 68.12% of visits assessed tightness, 71.60% of visits discussed bending or stooping, 65.77% of visits discussed putting on shoes, 65.84% of visits discussed sleeping, 65.65% of visits discussed standing up for an hours, 65.47% of visits discussed going up or down a flight of stairs, 65.95% of visits discussed walking through a store, 64.74% of visits discussed driving for an hour, 65.26% of visits discussed preparing a meal, 64.17% of visits discussed yard work, 65.41% of visits discussed picking up items off the floor (Table 1). This pattern of missingness should be considered when interpreting summary statistics and designing subsequent analyses.

Symptom or Function Measurement	Percent of Complete Data
Pain	74.51%
Numbness	68.48%
Tingling	67.48%
Burning	68.00%
Tightness	68.12%
Bending or stooping	71.60%
Putting on shoes	65.77%
Sleeping	65.84%
Standing up for an hour	65.65%
Going up or down a flight of stairs	65.47%
Walking through a store	65.95%
Driving for an hour	64.74%
Preparing a meal	65.26%
Yard work	64.17%
Picking up items from the floor	65.41%

Table 1: Data completeness per symptom or functional measurement

3.2. Demographics and Treatment

The mean age of patients in this cohort was 70.32 years (SD = 11.12), with ages ranging from 20 to 101 years (Figure 1). Patients received an average of 23.5 treatments (SD = 26.7), with a maximum of 243 sessions. The median number of treatments was 15, while the median "final treatment number" per patient was 33, suggesting extended engagement for many patients in this study.

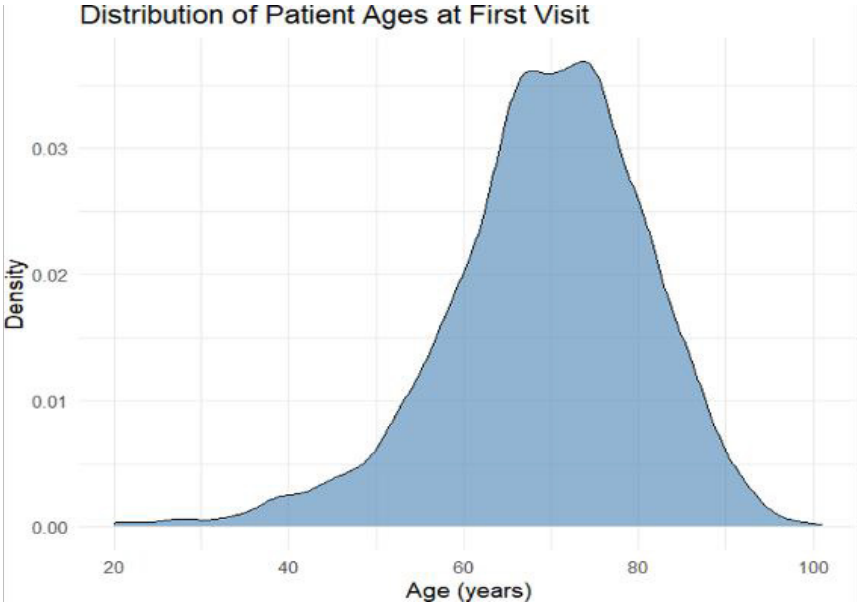

Figure 1: Ages of patients on their initial visit. The two modes are likely male vs. female

3.3. Symptom Severity at First Visit

At the initial treatment session, patients reported moderate levels of sensory symptoms on a 0–10 scale. The average pain severity was 5.15 (SD = 3.39), the average numbness severity was 5.51 (SD = 3.37), the average tingling severity was 5.00 (SD = 3.40), the average burning severity was 4.05 (SD = 3.69), and the average tightness severity was 4.67 (SD = 3.60). These values indicate that patients typically began treatment with moderate to moderately severe symptom burden across multiple domains.

3.4. Functional Limitations at First Visit

At the initial treatment session, patients also reported difficulty with everyday activities on a 1–5 scale, where higher scores indicate greater impairment. The average reported difficulty level for standing for an hour was 3.38 (SD = 1.53), the average reported difficulty level for going up or down stairs was 3.24 (SD = 1.47), the average reported difficulty level for walking through a store was 3.08 (SD = 1.45), the average reported difficulty level for driving for an hour was 2.53 (SD = 1.53), the average reported difficulty level for preparing a meal was 2.49 (SD = 1.40), the average reported difficulty level for doing yard work was 3.25 (SD = 1.62), and the average reported difficulty level for picking up items from the floor was 2.86 (SD = 1.44). These figures suggest moderate functional limitations at treatment onset, especially for mobility and endurance-related tasks.

3.5. Treatment Completion Patterns

Regarding treatment completion rates, 2,224 patients (62%) completed at least 12 treatments, 1,260 patients (35%) completed at least 24 treatments, 592 patients (16%) completed at least 36 treatments, and 359 patients (10%) completed at least 48 treatments (Figure 2). Early discontinuation was also standard: 192 patients (5%) stopped after just one treatment, and 778 patients (22%) discontinued before completing six treatments.

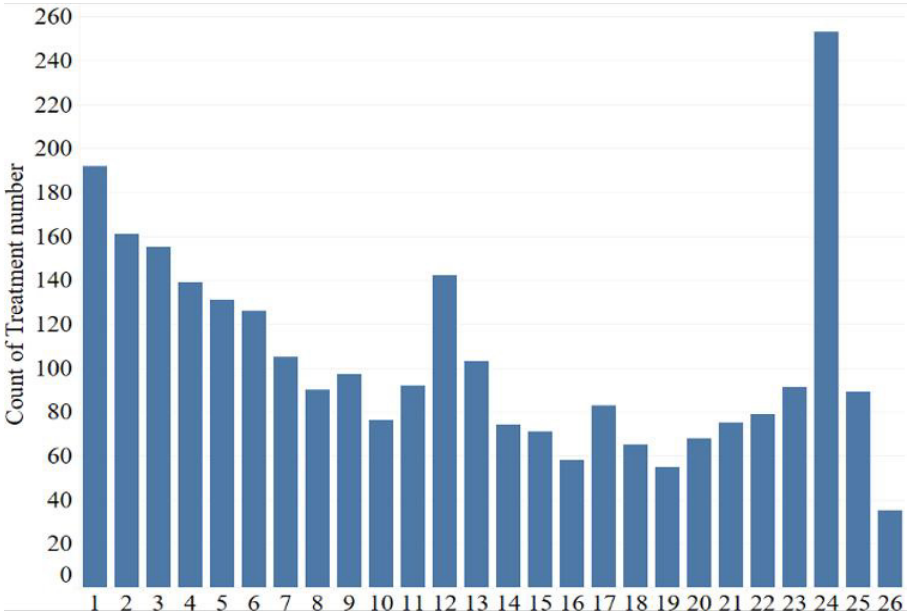

Figure 2: Distribution of patients by final treatment number. Each bar represents the number of patients whose final recorded treatment session corresponded to a specific treatment number. This visualization highlights common points of discontinuation or completion within the treatment protocol. Peaks at 12 and 24 suggest alignment with standard plan increments, while early drop-offs reflect partial adherence or early opt-out

3.6. Baseline Symptom and Functional Differences

We compared baseline values, such as age, pain severity, and burning severity, at treatment session 1 between patients who completed treatment (≥11 sessions) and those who stopped early (≤3 sessions), using both statistical significance (p values) and clinical significance (based on minimally essential differences). Regarding age, early stoppers were significantly younger, with an average age of 67.4 years, compared with completers, who had an average age of 70.2 years. However, this had a small effect size (d = –0.25) that may nonetheless reflect meaningful differences in treatment persistence by age. Although pain scores were significantly higher among early stoppers ($p < .001$), the difference, with an average change of 0.83 (d = 0.24), did not meet the threshold for clinical meaningfulness. Burning was the only symptom to meet both statistical ($p < .01$) and clinical thresholds with a difference of 0.58 (d = 0.16) based on a ≥0.5-point difference on a 0–10 scale. This may indicate that patients with more intense baseline burning sensations were more likely to discontinue early. Finally, all other differences in symptoms and function were statistically significant but clinically small (e.g., differences <0.5 on a 1–5 scale or <1.0 on a 0–10 scale), with effect sizes ranging from 0.06 to 0.28, well below the threshold for medium effects.While many symptoms showed statistically significant differences between groups, only burning approached a level of clinical concern, and most other

differences, while real, were likely too small to affect patient experience or clinical decision-making. This suggests that early discontinuation may be driven more by individual context (e.g., age, expectations, life constraints) than by symptom burden alone.

3.7. Early Non-Response and Treatment Discontinuation

We examined whether patients who discontinued treatment early (≤3 sessions) were more likely to show no improvement in symptoms or functional outcomes between sessions 1 and 3 than those who completed treatment (≥11 sessions). Non-response was defined as a score at session 3 that was equal to or worse than at session 1. Findings showed no evidence that early stoppers were more likely to be non-responders, supporting the conjecture that early discontinuation may be driven more by individual context.

3.8. Efficacy

We assessed treatment efficacy across five core symptoms: pain, numbness, tingling, burning, and tightness. We compared baseline values (T1) to follow-up assessments at treatment 2 (T2), treatment 6 (T6), and treatment 12 (T12). Analyses included only patients with paired measurements at both time points.

For each symptom, we calculated the mean change in score (negative values indicate improvement), the percentage of patients demonstrating improvement, and the statistical significance of the change using paired t-tests.Across all symptoms, the mean change values became more negative with successive treatments, indicating progressive symptom reduction over time. The proportion of patients reporting improvement also increased between T2 and T12, with many symptoms showing that nearly half of the patients improved by T12. All changes were statistically significant ($p < 0.001$), suggesting the observed improvements are unlikely to be due to chance.

3.9. Pain

A steady reduction in pain scores was observed, with the mean change increasing in magnitude from –0.31 at the first follow-up (T2) to –0.97 at T12. The proportion of patients reporting improvement rose from 30.6% at T2 to nearly half (47.6%) by T12 (Table 2).

Comparison	n	Mean Change	% Improved	p-value
T1 → T2	2512	-0.311	30.6	< 0.001
T1 → T6	1975	-0.712	45.2	< 0.001
T1 → T12	2505	-0.967	47.6	< 0.001

Table 2: Comparison of pain scores between T1 and T2, T1 and T6, and T1 and T12

3.10. Numbness

Numbness scores followed a similar trajectory, with early improvement evident at T2 and larger gains by T12. Over half of patients (53.0%) reported improvement at T12, the highest percentage across all symptoms (Table 3).

Comparison	n	Mean Change	% Improved	p-value
T1 → T2	2365	-0.304	29.9	< 0.001
T1 → T6	1863	-0.789	47.3	< 0.001
T1 → T12	**1422**	**-1.060**	**53.0**	**< 0.001**

Table 3: Comparison of numbness scores between T1 and T2, T1 and T6, and T1 and T12

3.11. Tingling

Tingling demonstrated the largest average change at T12 (–1.12), with over half of patients (50.8%) showing improvement. Notably, substantial changes were already present by T6 (Table 4).

Comparison	n	Mean Change	% Improved	p-value
T1 → T2	2315	-0.335	29.2	< 0.001
T1 → T6	1821	-0.764	45.7	< 0.001
T1 → T12	1376	-1.120	50.8	< 0.001

Table 4: Comparison of tingling scores between T1 and T2, T1 and T6, and T1 and T12

3.12. Burning

Although mean changes in burning scores were more minor in magnitude than for pain or tingling, improvement was still evident, with 41.6% of patients improving by T12 and all comparisons reaching statistical significance (Table 5).

Comparison	n	Mean Change	% Improved	p-value
T1 → T2	2347	-0.231	25.4	< 0.001
T1 → T6	1858	-0.559	37.8	< 0.001
T1 → T12	1412	-0.695	41.6	< 0.001

Table 5: Comparison of burning scores between T1 and T2, T1 and T6, and T1 and T12

3.13. Tightness

Tightness scores showed progressive improvement across treatments, with 45.0% of patients reporting better scores by T12. The mean change increased in magnitude over time, from –0.25 at T2 to –0.72 at T12.

Comparison	n	Mean Change	% Improved	p-value
T1 → T2	2311	-0.254	28.4	< 0.001
T1 → T6	1825	-0.530	40.1	< 0.001
T1 → T12	1395	-0.724	45.0	< 0.001

Table 6: Comparison of tightness scores between T1 and T2, T1 and T6, and T1 and T12

3.14. Symptom Trajectories Across 12 Treatments

Figure 3 below displays the mean symptom scores for pain, numbness, tingling, burning, and tightness across twelve treatment sessions. All symptoms showed steady improvement from baseline (T1) to the twelfth session (T12), indicated by declining mean scores over time. The most pronounced early improvements were observed between T1 and T2, followed by a gradual, sustained reduction in symptom severity in subsequent sessions.

Burning demonstrated the largest relative decrease, dropping from a baseline mean of 4.05 to 3.22 at T12. Pain, tingling, and tightness followed similar improvement trajectories, each declining by approximately 1 to 1.2 points on the scale. Numbness, while also improving, remained the highest-rated symptom at all time points, decreasing from 5.51 at baseline to 4.37 at T12. These results indicate that the treatment program yielded consistent and clinically meaningful reductions in symptom severity, with improvements evident early in the course and maintained through the twelfth session.

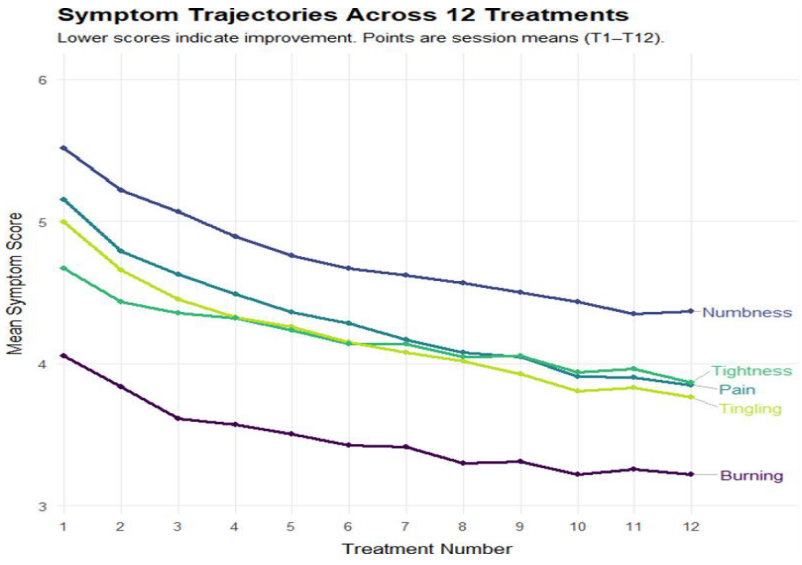

Figure 3: Symptom Trajectories by Treatment Number

3.15. Functional Task Outcomes

Analysis of patients with complete paired data from baseline (T1) to 12 treatments (T12) demonstrated statistically significant functional improvements in 8 of the 10 assessed daily tasks, including, standing up for an hour ($p<0.001$), bending or stooping ($p<0.001$), putting on shoes ($p<0.001$), going up or down a flight of stairs ($p<0.001$), walking through a store ($p<0.001$), picking up items from the floor ($p<0.001$), sleeping ($p=0.002$), and doing yard work ($p=0.002$) (Table 7). Tasks showing the largest improvement include standing up for an hour, with a mean change of -0.277; bending or stooping, with a mean shift of -0.194; and going up or down stairs, with a mean change of -0.216 (Table 7).

Task	n	Mean Change	% Improved	p-value
Standing up for an hour	1349	-0.277	30.7	< 0.001
Bending or stooping	1435	-0.194	28.4	< 0.001
Putting on shoes	1339	-0.119	24.3	< 0.001
Going up or down a flight of stairs	1308	-0.216	27.6	< 0.001
Walking through a store	1350	-0.144	24.8	< 0.001
Picking up items from the floor	1338	-0.153	25.9	< 0.001
Sleeping	1335	-0.101	24.0	0.002
Preparing a meal	1328	-0.0346	18.1	0.232
Yard work	1304	-0.108	19.9	0.002
Driving for an hour	1322	-0.0484	19.1	0.129

Table 7: Function outcome comparison from T1 to T12

Although the average changes were modest in magnitude (typically between -0.10 and -0.28 on the task scale), the statistical significance reflects the large sample sizes and consistency of improvement across participants. However, two tasks, preparing a meal ($p=0.232$) and driving for an hour ($p=0.129$), did not reach statistical significance, suggesting that either these activities were less affected by the condition at baseline or that improvements in these domains may require more time, targeted intervention, or are less sensitive to the treatment effects. Overall, the results indicate that completing the full 12-treatment course was associated with measurable functional gains in most daily activities assessed, particularly in mobility-related tasks.

3.16. Overall Impact

From T1 to T12, all five symptoms showed statistically significant mean reductions, with the most considerable changes observed for tingling (–1.12), numbness (–1.06), and pain (–0.97). Over half of participants reported improvement in these top three symptoms, and 56–61% met criteria for clinically meaningful change. Burning and tightness also improved, though to a slightly lesser extent (Table 8).

Functional tasks demonstrated smaller but measurable gains. The largest changes were for standing up for an hour (–0.28) and bending or stooping (–0.19), with 28–31% of participants improving in each. Other tasks showed modest or minimal change, with improvement rates still notable but generally below 26% (Table 8).

Domain	Measure	n	Mean change	95% CI	Cohen's d	% Improved (any)	% Clinically Meaningful
Symptom	Burning	1412	-0.695	-0.867, -0.522	-0.21	41.6	60.7
Symptom	Numbness	1422	-1.06	-1.216, -0.909	-0.36	53	60.1
Symptom	Pain	1505	-0.967	-1.122, -0.811	-0.31	47.6	56.9
Symptom	Tightness	1395	-0.724	-0.9, -0.548	-0.22	45	57.9
Symptom	Tingling	1376	-1.12	-1.294, -0.955	-0.35	50.8	60.9
Task	Bending Or Stooping	1435	-0.194	-0.252, -0.135	-0.17	28.4	28.4
Task	Driving For An Hour	1322	-0.048	-0.111, 0.014	-0.04	19.1	19.1
Task	Going Up Or Down A Flight Of Stairs	1308	-0.216	-0.28, -0.152	-0.18	27.6	27.6
Task	Picking Up Items From The Floor	1338	-0.153	-0.212, -0.095	-0.14	25.9	25.9
Task	Preparing A Meal	1328	-0.035	-0.091, 0.022	-0.03	18.1	18.1
Task	Putting On Shoes	1339	-0.119	-0.176, -0.061	-0.11	24.3	24.3
Task	Sleeping	1335	-0.101	-0.164, -0.038	-0.09	24	24
Task	Standing Up For An Hour	1349	-0.277	-0.342, -0.211	-0.23	30.7	30.7
Task	Walking Through A Store	1350	-0.144	-0.202, -0.087	-0.13	24.8	24.8
Task	Yard Work	1304	-0.108	-0.178, -0.039	-0.08	19.9	19.9

Figure 8: Summary of symptom and functional task changes from T1 to T12.

4. Discussion

This study demonstrates the strong overall efficacy of the PNS NeoGen device in treating peripheral neuropathy. The treatment produced statistically significant reductions across all measured symptoms from T1 to T12. The largest improvements were seen in tingling (–1.12), numbness (–1.06), and pain (–0.97), with over half of patients improving and roughly 57–61% achieving clinically meaningful change. Burning and tightness were also notably enhanced, with 41–45% of patients reporting improvement and 57–61% meeting clinical thresholds.

This is one of the largest studies to date investigating PNS use for peripheral neuropathies, comprising 77,969 treatment-specific records from 3,588 unique patients. In addition to the large sample size, our study also measured multiple variables across symptoms and functional metrics. Many previously published studies on the efficacy of PNS have addressed only symptom improvement, especially pain relief, and generalized functional improvement in activities of daily living. By systematically evaluating symptom-specific outcomes and discrete activities of daily living, this study provides greater clarity regarding the therapeutic effects of PNS in chronic pain and underscores opportunities for further clinical improvement. Previous studies on the use of PNS for treating peripheral neuropathy refractory to conservative management have demonstrated similar results regarding reduction of pain scores. One retrospective study by Ellen Lin included 63 patients who received PNS therapy. In this study, the average baseline pain score was 7.24, and the average pain score 2-3 weeks after implantation of the PNS device was 3.43, with 84% of patients reporting a reduction in pain at the 2-3 week follow-up appointment [22]. Additionally, a retrospective review of volunteer surveys conducted by Abd-Elsayed et al. included patients with chronic pain who engaged in noninvasive neuromodulation therapy. The results of this study demonstrated an overall pain reduction of 46%, and all functional metrics were improved, with the largest improvements reported in mood and sleep at over 47% [23]. Finally, a similar study conducted by Abd-Elsayed et. al. also investigated the use of PNS therapy for patients with chronic pain. This study demonstrated a statistically significant difference between the average preoperative pain score (6.36) and the average postoperative pain score (4.19), and a mean patient-reported percent improvement in pain following PNS therapy of 49.04% [24]. Furthermore, our study's results support the efficacy of PNS reported in previous literature. None of these previous studies used a device such as the NeoGen frequency neuromodulation device to enhance mitochondrial ATP and support potential cellular regeneration. While symptom relief was substantial, improvements in functional tasks were minor. The largest gains were seen in standing up for an hour (–0.28) and bending or stooping (–0.19), with 28–31% of patients improving. Most other tasks showed 18–26% improvement rates, suggesting functional recovery lags behind symptom relief for many patients. In a retrospective case series by Warner et Al. exploring outcomes of PNS for chronic pain, patients reported a median functional improvement in activities of daily living at 6 months post-implantation of 73%, with a range of 50% to 88% [25]. Although the improvement in functional tasks was lower in our study, this may be due to several factors. First, the treatment duration was shorter in our study. While the previously mentioned study examined functional outcomes after 6 months of treatment, patients in our study typically received only 12 treatments within 1 month, suggesting that the treatment's longevity could further improve functional outcomes.

Additionally, previous reports have assessed overall functional outcomes, whereas our study assessed individual activities of daily living [26]. This could affect the degree of reported improvement, since patients can specifically identify and assess their ability to complete a task rather than generalizing it to their daily functioning. As such, increasing the duration of treatment or adding adjunctive therapies or rehabilitation would likely improve functional metrics to rates similar to those seen in previous studies conducted for 6 or more months. While many patients in this study experienced symptomatic relief and functional recovery, a meaningful subset did not show clinically significant changes, especially on lower-baseline or task-related measures. Even among high responders, most patients retained some level of symptoms or task difficulty at T12, consistent with expectations for chronic neuropathic and musculoskeletal conditions. This highlights the need for tailored interventions for those with persistent limitations and reinforces the importance of long-term maintenance or booster strategies. For example, in patients where PNS did not completely resolve symptoms, a multimodal approach is recommended that combines traditional therapies with PNS to increase the potential for long-term pain relief. This could include first-line neuropathic agents such as gabapentin, selective norepinephrine reuptake inhibitors (SNRIs), or tricyclic antidepressants (TCAs), topical therapies, or other interventional pain procedures such as radiofrequency ablation (RFA), nerve blocks, or spinal cord stimulation. Additionally, emerging regenerative and biologic therapies, such as platelet-rich plasma for nerve regeneration or stem cell-based therapies to promote nerve repair, may offer more permanent relief for patients with more severe conditions; however, current research is limited [27,28]. Furthermore, for an overwhelming majority of patients, PNS should be one component of a comprehensive neuropathic pain strategy, and individualized treatment plans should be utilized to improve patient outcomes and quality of life.

4.1. Recommendations

Based on the results of this study, the following recommendations have been developed to help physicians using PNS in patients with chronic pain improve the efficacy of neuromodulation therapy and increase patient satisfaction. To tailor support for functional recovery, physical therapy or functional training for patients whose symptom relief outpaces functional gains should be integrated into this treatment protocol. For partial responders, exploring adjunctive or alternative therapies for patients who do not meet clinically meaningful thresholds by mid-treatment may help enhance the protocol. It is also essential to track the relationships between symptoms and functions by analyzing whether symptom improvements translate into functional gains over more extended time frames and by identifying when additional support is needed. For patients with chronic conditions, incorporating maintenance strategies and developing booster protocols to sustain benefits, particularly for those showing a strong initial response, could improve overall outcomes and patient satisfaction. Finally, it is essential to investigate attrition factors by conducting structured surveys and qualitative interviews with patients who discontinue treatment early, and potentially implementing exit interviews for all first-time patients. All together, these recommendations serve to enhance the use of PNS to provide long-term pain relief and improve quality of life for those suffering from chronic pain.

5. Conclusions

In conclusion, this analysis confirms that the NeoGen treatment protocol delivers substantial, clinically meaningful reductions in neuropathic symptom severity for most patients, with more modest but measurable gains in functional ability. The most apparent benefits are seen in sensory symptoms, where over half of patients achieve meaningful improvement. In contrast, task-based measures may require longer treatment, adjunctive therapies, or targeted rehabilitation to achieve similar success rates.

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