

A Combined Treatment Protocol for Patients With Diabetic Peripheral Neuropathy

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A physical therapy approach using monochromatic infrared energy and a balance program was shown to be effective in significantly reducing fall risk, reversing the loss of protective sensation, and improving functional ability.

The progressive symptoms of diabetic peripheral neuropathy (DPN) are some of the most frequent presentations of patients seeking care at the VHA. Patients with DPN often experience unmanageable pain in the lower extremities, loss of sensation in the feet, loss of balance, and an inability to perform daily functional activities.¹ In addition, these patients are at significant risk for lower extremity ulceration and amputation.² The symptoms and consequences of DPN are strongly linked to chronic use of pain medications as well as increased fall risk and injury.³ The high health care usage of veterans with these complex issues makes DPN a significant burden for the patient, the VHA, and society as a whole.

At the William Jennings Bryan Dorn VA Medical Center (WJBDVAMC) in Columbia, South Carolina, 10,763 veterans were iden-

tified to be at risk for limb loss in 2014 due to loss of protective sensation and 5,667 veterans diagnosed with DPN were treated in 2014.⁴ Although WJBDVAMC offers multiple clinics and programs to address the complex issues of diabetes and DPN, veterans oftentimes continue to experience uncontrolled pain, loss of protective sensation, and a decline in function even after diagnosis.

One area of improvement the authors identified in the WJBDVAMC Physical Medicine and Rehabilitation Services Department was the need for an effective, nonpharmacologic treatment for patients who experience DPN. As a result, the authors designed a pilot research study to determine whether or not a combined physical therapy intervention of monochromatic near-infrared energy (MIRE) treatments and a standardized balance exercise program would help improve the protective sensation, reduce fall risk, and decrease the adverse impact of pain on daily function. The study was approved by the institutional review board (IRB) and had no outside source of funding.

BACKGROUND

Current treatments for DPN are primarily pharmacologic and are viewed as only moderately effective, limited by significant adverse effects (AEs) and drug interactions.⁵ Patients in the VHA at risk for amputation in low-, moderate-, and high-risk groups total 541,475 and 363,468 have a history of neuropathy. They are considered at risk due to multiple, documented factors, including weakness, callus, foot deformity, loss of protective sensation, and/or history of amputation.⁴ Neuropathy can affect tissues throughout the body, including organs, sensory neurons, cardiovascular status, the autonomic system, and the gastrointestinal tract as it progresses.

Individuals who develop DPN often experience severe, uncontrolled pain in the lower extremities, insensate feet, and decreased proprioceptive skills. The functional status of individuals with DPN often declines insidiously while mortality rate increases.⁶ Increased levels of neuropathic pain often lead to decreased activity levels, which, in turn, contribute to

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decreased endurance, poorly managed glycemic indexes, decreased strength, and decreased independence.

Additional DPN complications, such as decreased sensation and muscle atrophy in the lower extremities, often lead to foot deformity and increased areas of pressure during weight bearing postures. These areas of increased pressure may develop unknowingly into ulceration. If a patient's wound becomes chronic and nonhealing, it can also lead to amputation. In such cases, early mortality may result.^{6,7} The cascading effects of neuropathic pain and decreased sensation place a patient with diabetes at risk for falls. Injuries from falls are widely known to be a leading cause of hospitalization and mortality in the elderly.⁸

Physical therapy may be prescribed for DPN and its resulting sequelae. Several studies present conflicting results regarding the benefits of therapeutic exercise in the treatment of DPN. Akbari and colleagues showed that balance exercises can increase stability in patients with DPN; whereas, a study by Kruse and colleagues noted a training program consisting of lower-extremity exercises, balance training, and walking resulted in minimal improvement of participants' balance and leg strength over a 12-month period.^{9,10} Recent studies have shown that weight bearing does not increase ulceration in patients with diabetes and DPN. This is contrary to previous assumptions that patients with diabetes and DPN need to avoid weight-bearing activities.^{11,12}

Transcutaneous electrical nerve stimulation (TENS), a modality often used in physical therapy, has been studied in the treatment of DPN with conflicting results. Gossrau and colleagues found that pain reduction with micro-TENS applied peripher-

ally is not superior to a placebo.¹³ However, a case study by Somers and Somers indicated that TENS applied to the lumbar area seemed to reduce pain and insomnia associated with diabetic neuropathy.¹⁴

Several recent research studies suggest that MIRE, another available modality, may be effective in treating symptoms of DPN. Monochromatic infrared energy therapy is a noninvasive, drug-free, FDA-approved medical device that emits monochromatic near-infrared light to improve local circulation and decrease pain. A large study of 2,239 patients with DPN reported an increase in foot sensation and decreased neuropathic pain levels when treated with MIRE.¹⁵

Leonard and colleagues found that the MIRE treatments resulted in a significant increase in sensation in individuals with baseline sensation of 6.65 Semmes-Weinstein Monofilament (SWM) after 6 and 12 active treatments as well as a decrease in neuropathic symptoms as measured by the Michigan Neuropathy Screening Instrument.¹⁶ Prendergast and colleagues noted improved electrophysical changes in both large and small myelinated nerve fibers of patients with DPN following 10 MIRE treatments.¹⁷ When studying 49 patients with DPN, Kochman and colleagues found 100% of participants had improved sensation after 12 MIRE treatments when tested with monofilaments.¹⁸

An additional benefit of MIRE treatment is that it can be safely performed at home once the patient is educated on proper use and application. Home DPN treatment has the potential to decrease the burden this population places on health care systems by reducing provider visits, medication, hospitalization secondary to pain, ulceration, fall injuries, and amputations.

METHODS

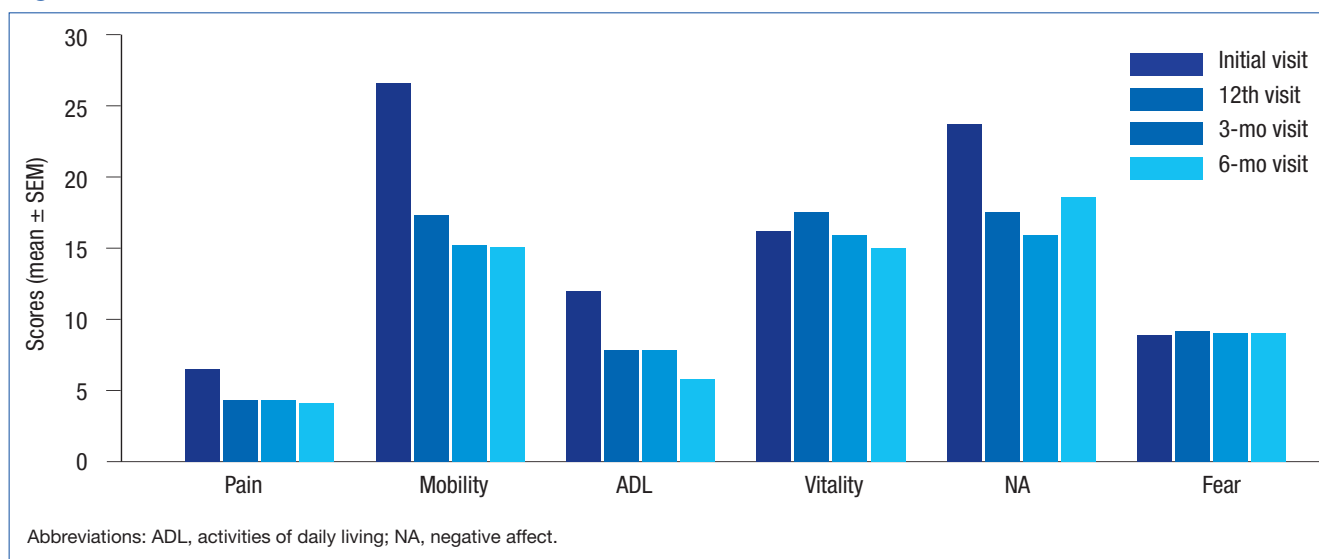
This was a prospective, case series pilot study designed to measure changes in patient pain levels using the visual analog scale (VAS) and Pain Outcomes Questionnaire-VA (POQ-VA), degree of protective sensation loss as measured by SWM, and fall risk as denoted by Tinetti scores from entry to 6 months. Informed consent was obtained prior to treatment, and 33 patients referred by primary care providers and specialty clinics met the criteria and enrolled in the study. Twenty-one patients completed the entire 6-month study. The nonparametric Friedman test with a Dunn's multiple comparison (DMC) post hoc test was used to analyze the data from the initial, 4-week, 3-month, and 6-month follow-up visits.

Setting and Participants

The study was performed in the Outpatient Physical Therapy Department at WJBDVAMC. Veterans with DPN who met the inclusion/exclusion criteria were enrolled. Inclusion criteria specified that the participant must be referred by a qualified health care provider for the treatment of DPN, be able to read and write in English, have consistent transportation to and from the study location, and be able to apply MIRE therapy as directed at home.

Exclusion criteria were subjects for whom MIRE or exercise were contraindicated. Subjects were excluded if they had medical conditions that suggested a possible decline in health status in the next 6 months. Such conditions included a current regimen of chemotherapy, radiation therapy, or dialysis; recent lower extremity amputation without prosthesis; documented active alcohol and/or drug misuse; advanced chronic obstructive pulmonary disease as defined as dyspnea at rest at

Figure 1. Pain Outcome Questionnaire-VA Subscores



least once per day; unstable angina; hemiplegia or other lower extremity paralysis; and a history of central nervous system or peripheral nervous system demyelinating disorders. Additional exclusion criteria included hospitalization in the past 60 days, use of any apparatus for continuous or patient-controlled analgesia; history of chronic low back pain with documented radiculopathy; and any change in pertinent medications in the past 60 days, including pain medications, insulin, metformin, and anti-inflammatories.

Interventions

Subjects participated in a combined physical therapy approach using MIRE and a standardized balance program. Patients received treatment in the outpatient clinic 3 times each week for 4 weeks. The treatment then continued at the same frequency at home until the scheduled 6-month follow-up visit. Clinic and home treatments included application of MIRE to bilateral lower extremities and feet for 30 minutes each as well as performance of a therapeutic exer-

cise program for balance.

In the clinic, 2 pads from the MIRE device (Anodyne Therapy, LLC, Tampa, FL) were placed along the medial and lateral aspect of each lower leg, and an additional 2 pads were placed in a T formation on the plantar surface of each foot, per the manufacturer’s recommendations. The T formation consisted of the first pad placed horizontally across the metatarsal heads and the second placed vertically down the length of the foot. Each pad was protected by plastic wrap to ensure proper hygiene and secured. The intensity of clinic treatments was set at 7 bars, which minimized the risk of burns. Home treatments were similar to those in the clinic, except that each leg had to be treated individually instead of simultaneously and home MIRE units are preset and only function at an intensity that is equivalent to around 7 bars on the clinical unit.

The standardized balance program consisted of a progression of the following exercises: ankle alphabet/ankle range of motion, standing lateral weight shifts, bilateral heel

raises, bilateral toe raises, unilateral heel raises, unilateral toe raises, partial wall squats, and single leg stance. Each participant performed these exercises 3 times per week in the clinic and then 3 times per week at home following the 12th visit.

Outcomes and Follow-up

The POQ-VA, a subjective quality of life (QOL) measure for veterans, as well as VAS, SWM testing, and the Tinetti Gait and Balance Assessment scores were used to measure outcomes. Data were collected for each of these measures during the initial and 12th clinic visits and at the 3-month and 6-month follow-up visits. The POQ-VA and VAS scores were self-reported and filled out by each participant at the initial, 12th, 3-month, and 6-month visits. The POQ-VA score has proven to be reliable and valid for the assessment of noncancer, chronic pain in veterans.¹⁹ The VAS scores were measured using a scale of 0 to 10 cm.

The SWM was standardized, and 7 sites were tested on each foot during the initial, 12th, 3-month, and

6-month visits: plantar surface of the distal great toe, the distal 3rd toe, the distal 5th toe, the 1st metatarsal head, the 3rd metatarsal head, the 5th metatarsal head, and the mid-plantar arch. At each site, the SWM was applied with just enough force to initiate a bending force and held for 1.5 seconds. Each site was tested 3 times. Participants had to detect the monofilament at least twice for the monofilament value to be recorded. Monofilament testing began with 6.65 SWM and decreased to 5.07, 4.56, 4.32, and lower until the patient was no longer able to detect sensation.

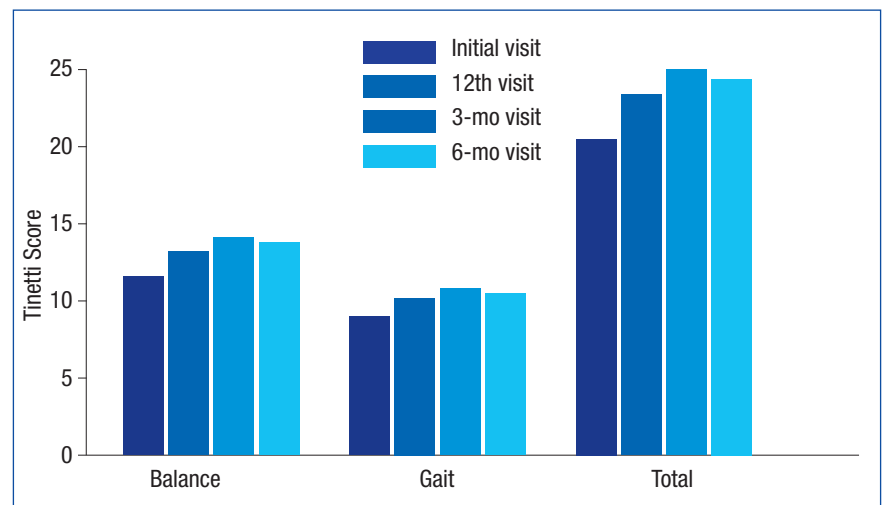
The Tinetti Gait and Balance Assessments was performed on each participant at the initial, 12th, 3-month, and 6-month visits. Tinetti balance, gait, and total scores were recorded at each interval.

RESULTS

Thirty-three patients, referred by primary care providers and specialty clinics, met the inclusion criteria and enrolled in the study. Twenty-one patients (20 men and 1 woman) completed the entire 6-month study. Causes for withdrawal included travel difficulties (5), did not show up for follow-up visits (4), lumbar radiculopathy (1), perceived minimal/no benefit (1), and unrelated death (1). No AEs were reported.

The Friedman test with DMC post hoc test was performed on the POQ-VA total score and subscale scores. The POQ-VA subscale scores were divided into the following domains: pain, activities of daily living (ADL), fear, negative affect, mobility, and vitality. The POQ-VA domains were analyzed to compare data from the initial, 12th, 3-month, and 6-month visits. The POQ-VA total score significantly decreased from the initial to the 12th visit ($P < .01$), from the

Figure 2. Tinetti Gait and Balance Assessment



initial to the 3-month ($P < .01$), and from the initial to the 6-month visit ($P < .05$). However, there was no significant change from the 12th visit to the 3-month follow-up, 12th visit to the 6-month follow-up, or the 3-month to 6-month follow-up.

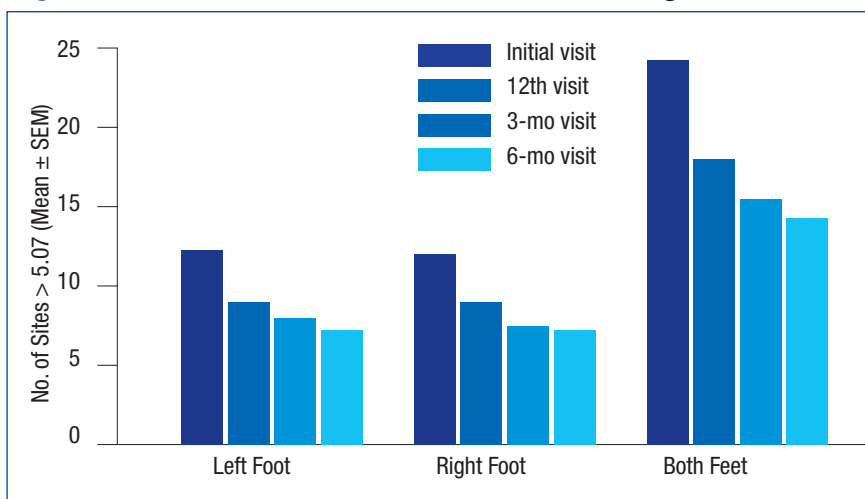
The POQ-VA pain score decreased significantly from the initial to the 12th visit ($P < .05$) and from the initial to the 6-month visit ($P < .05$). However, there was no significant interval change from the initial to the 3-month, the 12th to 3-month, 12th to 6-month, or 3-month to 6-month visit (Figure 1). The POQ-VA vitality scores and POQ-VA fear scores did not yield significant changes. The POQ-VA negative affect scores showed significant improvement only between the initial and the 3-month visit ($P < .05$) (Figure 2). The POQ-VA ADL scores showed significant improvement in the initial vs 3-month score ($P < .05$). The POQ-VA mobility scores were significantly improved for the initial vs 12th visit ($P < .01$), initial vs 3-month visit ($P < .01$), and the initial vs 6-month visit ($P < .001$) (Figure 1).

Analysis of VAS scores revealed a significant decrease at the 6-month

time frame compared with the initial score for the left foot ($P < .05$). Further VAS analysis revealed no significant difference between the initial and 6-month right foot VAS score. When both feet were compared together, there was no significant difference in VAS ratings between any 2 points in time.

Analysis of Tinetti Total Score, Tinetti Balance Score, and Tinetti Gait Score revealed a significant difference between the initial vs 3-month visit for all 3 scores ($P < .001$, $P < .001$, and $P < .05$, respectively). In addition, Tinetti Total ($P < .001$) and Tinetti Balance ($P < .01$) scores were significantly improved from initial to the final 6-month visit. There were no significant findings between interim scores of the initial and 12th visits, the 12th and 3-month visits, or the 3-month and 6-month scores (Figure 2).

Analysis of SWM testing indicated a significant decrease in the total number of insensate sites (> 5.07) when both feet were grouped together between the initial and 3-month visits ($P < .05$) as well as the initial and 6-month ($P < .01$) visits. When the left and right feet were

Figure 3. Semmes-Weinstein Monofilament Testing

compared independently of each other, there was a significant decrease in the number of insensate sites between the initial and 6-month visits ($P < .01$ for both) (Figure 3).

DISCUSSION

This study investigated whether or not a multimodal physical therapy approach would reduce several of the debilitating symptoms of DPN experienced by many veterans at WJBDVAMC. The results support the idea that a combined treatment protocol of MIRE and a standardized exercise program can lead to decreased POQ-VA pain levels, improved balance, and improved protective sensation in veterans with DPN. Alleviation of these DPN complications may ultimately decrease an individual's risk of injury and improve overall QOL.

Because the POQ-VA is a reliable, valid self-reported measure for veterans, it was chosen to quantify the impact of pain. Overall, veterans who participated in this study perceived decreased pain interference in multiple areas of their lives. The most significant findings were in overall QOL, household and community mobility, and pain ratings. This sug-

gests that the combined treatment protocol will help veterans maintain an active lifestyle despite poorly controlled diabetes and neuropathic pain.

Along with decreased pain interference with QOL, participants demonstrated a decrease in fall risk as quantified by the Tinetti Gait and Balance Assessment. The SWM testing showed improved protective sensation as early as 3 months and continued through the 6-month visit. As protective sensation improves and fall risk decreases, the risk of injury is lessened, fear of falling is decreased, and individuals are less likely to self-impose limitations on daily activity levels, which improves QOL. In addition, decreased fall risk and improved protective sensation can reduce the financial burden on both the patient and the health care system. Many individuals are hospitalized secondary to fall injury, nonhealing wounds, resulting infections, and/or secondary complications from prolonged immobility. This treatment protocol demonstrates how a standardized physical therapy protocol, including MIRE and balance exercises, can be used preventively to reduce both the

personal and financial impact of DPN.

It is interesting to note that some POQ-VA and Tinetti subscores were significantly improved at 3 months but not at 6 months. The significance achieved at 3 months may be due to the time required (ie, > 12 visits) to make significant physiological changes. The lack of significance at 6 months may be due to the natural tendency of participants to less consistently perform the home exercise program and MIRE protocol when unsupervised in the home. Differences in the VAS and POQ-VA pain score ratings were noted in the data. The POQ-VA pain rating scale indicated significant improvement in pain levels over the course of the study. However, when asked about pain using the 10-cm VAS, patients reported no significant improvements. This may be because veterans are more familiar with the numerical pain rating scale and are rarely asked to use the 10-cm VAS. It may also be because the POQ-VA pain rating asks for an average pain level over the previous week, whereas the 10-cm VAS asks for pain level at a discrete point in time.

Historically, physical therapy has had little to offer individuals with DPN. As a result of this study, however, a standardized treatment program for DPN has been implemented at the WJBDVAMC Physical Therapy Clinic. Referred patients are seen in the clinic on a trial basis. If positive results are documented during the clinic treatments, a home MIRE unit and exercise program are provided. The patients are expected to continue performing home treatments of MIRE and exercise 3 times a week after discharge.

Strengths and Limitations

Strengths of the study include a stringent IRB review, control of

medication changes during the study through alerts to all VA providers, and a standardized MIRE and exercise protocol. An additional strength is the long duration of the study, which included supervised and unsupervised interventions that simulate real-life scenarios.

Limitations of the study include a small sample size, case-controlled design rather than a randomized, double-blinded study, which can contribute to selection bias, inability to differentiate between the benefits of physical therapy alone vs physical therapy and MIRE treatments, and retention of participants due to travel difficulties across a wide catchment area.

This pilot study should be expanded to a multicenter, randomized, double-blinded study to clarify the most beneficial treatments for individuals with diabetic neuropathy. Examining the number of documented falls pre- and postintervention may also be helpful to determine actual effects on an individual's fall risk.

CONCLUSION

The use of a multimodal physical therapy approach seems to be effective in reducing the impact of neuropathic pain, the risk of amputation, and the risk of falls in individuals who have pursued all standard medical options but still experience the long-term effects of DPN. By adhering to a standardized treatment protocol of MIRE and therapeutic exercise, it seems that the benefits of this intervention can be maintained over time. This offers new, nonconventional treatment options in the field of physical therapy for veterans whose QOL is negatively impacted

by the devastating effects of diabetic neuropathy. ●

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