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*Original Article*

# Effect of high-intensity laser versus moderate-intensity aerobic exercise on diabetic polyneuropathy patients

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**Abstract:**

**Objectives**: This study was conducted to determine the impact of high-intensity laser versus moderate-intensity aerobic exercise on diabetic polyneuropathy patients **Methods**: Sixty diabetic males were selected from the Deraya University Physical Therapy Center in Minia to participate in this study, which was conducted from June 2024 to January 2025. The ages of the participants ranged from 30-50 years with BMI ranged from 25 to 29.9. The participants were divided randomly into two groups. Group A received high-intensity laser therapy three times per week for twelve weeks, and Group B received moderate-intensity aerobic exercises in the form of walking on a treadmill machine three times per week for eight weeks. Data were collected on sensory and motor nerve conduction studies as well as lower extremity functional assessment [LEFS] for both groups before and following treatment. **Results**: Compared to group B, group A showed a decrease in peroneal latency and a highly statistically significant increase in peroneal conduction velocity and amplitude. In addition, group A showed a decrease in sural latency and a highly statistically significant increase in sural amplitude when compared to group B. After eight weeks, group A's LEFS significantly improved when compared to group B's. **Conclusions**: Both groups had beneficial effects in favor of group A.

**Keywords:** high-intensity laser; aerobic exercise; diabetes mellitus; polyneuropathy.

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## 1. Introduction:

Research by the International Diabetes Federation [IDF] has revealed a rapid increase in the prevalence of type 2 diabetes mellitus [T2DM] worldwide **[1].** Type 2 DM is frequently linked to lifestyle factors such as dietary habits and physical activity levels. The International Diabetes Federation has undertaken some research confirming the spike in the incidence of Type 2 diabetes worldwide. It is already established that type 2 DM is associated with several lifestyle elements, which also include food consumption and exercising.

The World Health Organization [WHO] also informed that mostly bulk of the 462 million people living with DM are located in the low to middle-income regions where healthcare access is highly restricted **[2].** Diabetic polyneuropathy is the most common type of polyneuropathy in developed regions of the world. Because the prevalence changes with the period of the disease, it is reasonable to estimate that about 50 % of the diabetic population is expected to eventually develop neuropathy. This estimation relies on several large studies **[3].** One of the most common and most difficult complications of diabetes in terms of its origin and persistence is Diabetic polyneuropathy [DPN] which accounts for length-dependent symmetrical sensorimotor polyneuropathy **[4].**

The most recent studies have reported the prevalence of DPN between 13% and 55% so of these subjects 25% to 50 % are likely to have painful neuropathy **[5].**

To prevent health deterioration, the active and passive detection of patients with DPN needs to be identified as a priority. There is a need to identify a rapid assessment that is simple to perform with high positive and negative predictive value for DPN. However, it remains a challenge to make a distinction **[6].** While the grading system created by the International Association for the Study of Pain's Neuropathic Pain Special Interest Group [NeuPSIG] is regarded as the gold standard for neuropathic pain, the Toronto Diabetic Neuropathy Expert Group's hierarchy grading system is currently the gold standard for DPN. These require a neurological evaluation, a medical history, and a neurophysiological or neuropathological assessment **[7].**

In individuals with diabetes, persistent neuropathic pain is associated with diminished quality of life [QoL], inadequate sleep, and manifestations of anxiety as well as depression. The effect of DPN alone—independent of pain, QoL, and mental health comorbidities remains ambiguous in type 2 diabetes patients. While some studies found a higher prevalence of depression among patients with both painless diabetes and painful DPN **[8],** another study found that the presence of DPN without painful symptoms did not affect mental health-related metrics. Exercise can improve mood and mental health. Regular aerobic exercise raises endorphin concentrations, which are potent analgesic and mood-enhancing neurotransmitters in the brain while lowering adrenal hormone levels. Additionally, it improves blood circulation, which strengthens neuronal tissues by increasing their oxygen supply **[9]**. Nerve conduction studies [NCSs] are the most objective, noninvasive evaluations of nerve function and are fundamental tools for secondary nerve damage estimation. For all small-fiber polyneuropathies, the NCS ceiling is the lack of impact on the sensory action potential due to peripheral nerve degenerative changes involving small myelinated and unmyelinated axons, which have an impact early in the evolution of diabetic peripheral neuropathy [DPN]. The sensory action potential is modified only after the recruitment of larger myelinated axons whose contribution to diabetes is usually as a late complication. Always correlate electrophysiology data with the clinical information available **[10].**

The application of a high-intensity laser [HIL] used in rehabilitation therapy has been claimed to be effective since it helps in swift recovery and offers immediate pain relief **[11].**

The main physiological actions of HIL comprise increased activity of particular intracellular enzymes, especially those in the Krebs cycle, along with enhanced transport of oxygen and usage of glucose, stimulation of the synthesis of nucleic acids, action of Na/K pumps of cellular membranes, increased activity of fibroblasts, phagocytosis, activation of metabolism at the level of the cell, local changes in some inflammatory mediators [for example, histamine with prostaglandins], and increase in levels of endorphins **[12].**

## 2. Materials and Methods:

60 male patients with type II diabetes, ages 30 to 50, with BMI ranged from 25 to 29.9 were included in the study; their mean age was 41.45 ± 1.62 years. Participants were chosen at random from the Deraya University Physical Therapy Center's outpatient clinic and split into two groups: 30 patients received high-intensity laser therapy [HIL], and the remaining 30 patients performed moderate-intensity aerobic exercise. Every participant had neuropathic lower limb symptoms, such as burning, tingling, pain, numbness, electric shock, and stabbing, which were verified by abnormal NCS.

Patients were excluded if they exhibited causes of sensory polyneuropathy unrelated to diabetes, including systemic diseases, infections, inflammatory conditions, drug effects, metal exposure, and hereditary factors, as well as contraindications for the use of hil [such as irradiation for malignancies as well as potential precancerous growth, irradiation among patients with cochlear implants, irradiation of endocrine glands, febrile conditions, epilepsy, pregnancy, and irradiation of freckles or tattoos, as well as the use of photosensitive medications]. Additionally, patients with contraindications to moderate-intensity aerobic exercise [including those with pacemakers, damaged skin, localized cancer,

epilepsy, hemorrhage, and infections], uncontrolled diabetes, fractures or deformities of any lower limb bones, osteoporosis, significant scar tissue or calluses on the feet, or diabetic foot were also excluded.

Every patient was asked to sign a consent form prior to the start of the treatment program, indicating his or her agreement to be part of the study. Prior to and following treatment, patients were given the lower extremity functional scale [LEFS], and they were given a thorough explanation of the treatment program and measurement equipment methods, as well as the treatment's aim.

**1.1. Treatment instruments:**

The LAZR-207/215 high-intensity laser device, with a power output of up to 15 W in continuous mode, has optimal therapeutic efficacy at a wavelength of 980 nm and is safe for operation. Documentation of treatment results with patient data cards with constant current/constant settings.

**1.2. Procedures of the study**

All patients were referred following a comprehensive medical evaluation and were diagnosed with type II diabetes accompanied by DPN in both feet.

**1.3. Therapeutic procedure:**

Sixty individuals with DPN were randomly assigned to two groups.

Group A:

The study included 30 patients with DPN who were advised to undergo HIL treatment for eight weeks.

Group B:

The study involved 30 patients with DPN who were advised to engage in moderate-intensity aerobic exercise, specifically walking on a treadmill at a speed of 3–4 miles per hour on a flat surface [0% incline] for 40 minutes, 3 times weekly over eight weeks.

Precautions:

Before laser application, the target areas were sanitized with 95% alcohol to reduce any backscatter or reflection from oily skin. The patient and therapist wore protective glasses, and the treatment parameters were calibrated following the Fitzpatrick scale to prevent overheating. No ointments, creams, lotions, or heating patches were applied to or near the treated area, and no therapies capable of altering body temperature, such as ultrasonography, thermal therapy, or electrotherapy, were utilized before laser treatment **[13].**

**High-intensity laser:**

In the HIL group, a standard handpiece equipped with a fixed spacer was used to maintain a consistent distance from the skin, perpendicular to the treatment area, with a laser beam diameter of 30 mm for each foot treatment, which was administered once daily, 3 times/week, for eight weeks.

Parameters:

The wavelength measured 1064 nm, accompanied by a power output of 5.00 W. The frequency employed was 25 Hz during the analgesic phase and continuous during the biostimulation phase, whereas the spacer size was 30 mm during both treatment phases **[14].**

**1.1. Method of application:**

Phase I [analgesic phase]:

Efficient pain management without adverse effects: the novel emission mode enables energy modulation to address joint and muscle pain promptly. The applicator was moved perpendicular to the foot in a series of continuous circular motions across the entire plantar surface of the foot as well as the tarsal tunnel. The application was performed from the center toward the outside, beginning approximately 5–7 cm from the most painful spot and forming three or four spirals. Each foot was treated for six minutes. The cumulative energy dose delivered during this phase was 4000 J.

Phase II [anti-inflammatory]:

Lasers control inflammatory processes by strongly stimulating tissues, inducing vasodilation, and increasing oxygenation, thus activating primary metabolic activities.

Phase III [biostimulation]:

Lasers increase tissue remodeling by increasing the levels of collagen and other energetic biological processes. The application was applied via continuous linear movements in the area that caused the pain. These movements generate warmth; hence, patients were asked about their thermal feelings to avoid static application. The region was heated, and the treatment duration was 10 minutes per foot. The cumulative energy delivered during this time was 4000 J. Rapid manual scanning of the deltoid region and the same areas treated in the first phase were required in the last phase until a total energy dose of 2000 J was reached.

The same physiotherapist administered these interventions on both feet of the patient during all sessions, and assessments of NCV for the motor common peroneal nerve along with the sensory sural nerve, as well as the LEFS, were conducted prior to and following treatment.

## 3. Results:

### 3.1. Statistical analysis:

Statistical analysis was performed with SPSS for Windows, version 26 [SPSS, Inc., Chicago, IL]. Before the final analysis, the data were examined for normality, homogeneity of variance, and the existence of outliers, with the p-value established at < 0.05. This analysis was conducted as a prerequisite for parametric testing of the difference analysis.
A repeated measures MANOVA test was conducted to compare the mean values of several parameters among the two groups, assessing significant differences at two testing intervals [pre- and post-intervention].

### 3.2. Results:

The present research had a total of sixty respondents who were male and had diabetic polyneuropathy. The patients were divided into two equal groups: n=30 in Group A [laser treatment high doses] and n=30 in Group B [moderate aerobic exercise]. Measurements for the two groups were taken before commencing the rehabilitation program [pre] and after completion of rehabilitation [post] for evaluation purposes.

There were no significant differences in the mean values for age, weight, height, and BMI for both groups of patients, as determined by the unpaired sample t-test, p values as shown in **Table 1**. Age [p = 0.378], weight [p = 0.403], height [p = 0.453], and BMI [p = 0.4174] were all in a normal range.

### 3.3. Peroneal nerve EMG

The means ± SDs of the right and left peroneal nerve NCV, amplitude, and motor latency are presented in **Table 2,** while variable means estimates for both group's pre and post-rehabilitation are illustrated in **Figures 1-6**. There were marked within-group differences in both groups A and B for post-rehabilitation measurements for all the peroneal nerve EMG measurements. In contrast, for the pre-rehabilitation assessment measures of the peroneal nerve, there was no marked difference between the two groups except for Rt and Lt peroneal nerve motor latency. Per the data, the difference between group peroneal nerve NCV was significant in the right and left sides; however, concerning the amplitude and motor latency, no significant difference between groups existed **(Table 2).**

### 3.4. Sural nerve EMG

The means ± SDs of the right and left sural nerve amplitudes along with motor latency are presented in **Table 2,** and the estimated marginal means of these variables before and after rehabilitation in both groups are shown in **Figures 7--10.** There were significant within-group differences in both groups A and B for the post-rehabilitation measurements for all the measures of the sural nerve EMG except for the left sural nerve motor latency. Furthermore, there was a substantial difference within both groups for all measures of the sural nerve used for the pre-rehabilitation assessment. There were significant between-group differences in the Rt and Lt sural nerve amplitudes but no significant between-group differences in the sural nerve motor latency (**Table 2**).

### 3.5. Lower extremity functional scale [LEFS]:

The mean ± SD of the LEFS is presented in Table 2 and the estimated marginal means before and after rehabilitation in both groups are shown in **Figure 11.** There were significant within-group differences in both groups A and B for the post-rehabilitation measure for LEFS. On the other hand, there were no significant within-group differences for either group in terms of the LEFS score at the pre-rehabilitation assessment. There were significant between-group differences in LEFS, as presented in **Table 2.**

**Table 1.** Descriptive statistics and the unpaired t test for demographic data in both groups.

| Variable | Mean ± SD | | t value | *P* value | Sig. |
|---|---|---|---|---|---|
| | Group A N = 30 | Group B N = 30 | | | |
| **Age [years]** | 41.45 ± 1.62 | 40.95 ± 1.83 | 0.8917 | 0.3785 | NS |
| **Weight [kg]** | 75.2 ± 4.42 | 76.3 ± 3.54 | 0.8467 | 0.4028 | NS |
| **Height [cm]** | 170.32 ± 3.95 | 171.21 ± 3.25 | 0.7584 | 0.4531 | NS |
| **BMI [kg/m²]** | 25.99±0.306 | 26.07±0.295 | 0.4204 | 0.4174 | NS |

*SD= Standard deviation, *t value=t statistic, *P value=probability, *Sig =Significance, *NS=non-significant

**Table 2: Mean ±SD and p values of nerve conduction studies before and after treatment in both groups:**

| Variable | Group A N = 30 | Group B N = 30 | p value [CI] | Group A N = 30 | Group B N = 30 | p value [CI] | Repeated measure MANOVA Mean difference | p value [CI] |
|---|---|---|---|---|---|---|---|---|
| | Pretreatment $\bar{x}$ ± SD | | | Posttreatment $\bar{x}$ ± SD | | | | |
| **Right peroneal NCV [m/sec]** | 35.09±2.07 | 35.65±1.86 | 0.391 [-1.85-0.74] | 35.68±1.11 | 37.63±1.55 | <0.001* [-2.83--1.06] | -1.250 | 0.001 [-1.961- -0.538] |
| **Left peroneal NCV [m/sec]** | 36.33±1.93 | 36.73±1.62 | 0.502 [-1.56-0.78] | 41.89±1.45 | 40±1.60 | <0.001* [0.89-2.90] | 0.751 | 0.049 [0.002-1.5] |
| **Right peroneal amplitude [mV]** | 2.29±0.56 | 2.50±0.48 | 0.216 [-0.56-0.13] | 3.63±0.50 | 3±0.88 | 0.010* [0.16-1.10] | 0.208 | 0.097 [-0.04-0.457] |
| **Left peroneal amplitude [mV]** | 2.45±0.60 | 2.37±0.44 | 0.625 [-0.26-0.43] | 3.58±0.51 | 3.10±0.87 | 0.049* [0.003-0.94] | 0.279 | 0.096 [-.05-0.610] |
| **Right sural amplitude [mV]** | 2.59±0.24 | 2.29±0.50 | 0.021 [0.48-0.56] | 6.74±0.80 | 2.79±0.71 | <0.001 [3.45-4.45] | 2.127 | <0.001 [1.85-2.40] |
| **Left sural amplitude [mV]** | 2.71±0.29 | 2.39±0.50 | 0.020 [0.05-0.59] | 7±0.82 | 3.26±0.80 | <0.001 [3.20-4.27] | 2.031 | <0.001 [1.72-2.34] |
| **Right peroneal motor latency [m/sec]** | 4.95±0.25 | 3.69±0.68 | <0.001* [0.92-1.59] | 3.58±0.51 | 4.53±0.51 | <0.001* [-1.28--0.61] | 0.156 | 0.184 [-0.08-0.39] |
| **Left Peroneal Motor Latency [m/sec]** | 5.27±0.21 | 4.64±1 | 0.012* [0.15-1.10] | 3.47±0.51 | 4±0.82 | 0.023* [-0.97--0.08] | 0.049 | 0.767 [-0.28-0.38] |
| **Right sural latency [m/sec]** | 7.08±0.26 | 6.58±0.51 | <0.001 [0.23-0.76] | 5±0.82 | 5.53±0.51 | 0.023 [-0.97--0.08] | -.013 | 0.922 [-0.28-0.25] |
| **Left sural latency [m/sec]** | 6.90±0.20 | 6.42±0.51 | <0.001 [0.23-0.73] | 5.37±0.68 | 5.58±0.51 | 0.288 [-0.61-0.81] | 0.135 | 0.270 [-0.11-0.38] |
| **LEFS** | 39.58±3.96 | 39±4.41 | 0.673 [-2.18-3.34] | 54.74±4.17 | 46.47±2.57 | <0.001 [5.98-10.54] | 4.421 | <0.001* [2.59-6.25] |

$\bar{x}$ Mean; SD, standard deviation; p value, level of significance

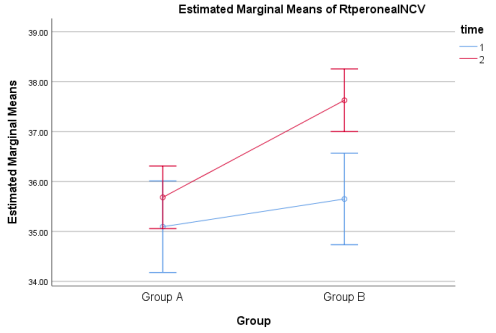


*Figure 1: Estimated marginal means of right peroneal NCV [m/sec] of both groups.*

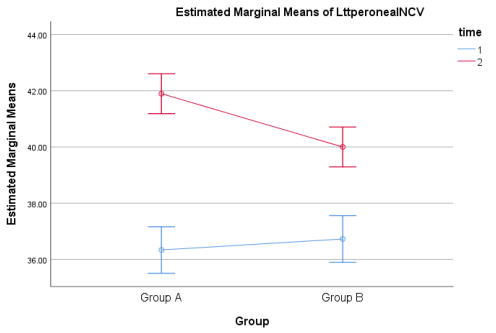


*Figure 2: Estimated marginal means of left peroneal NCV [m/sec] of both groups.*

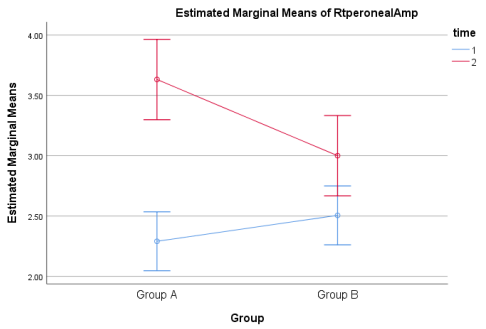


*Figure 3: Estimated marginal means of right peroneal amplitude [mV] of both groups.*

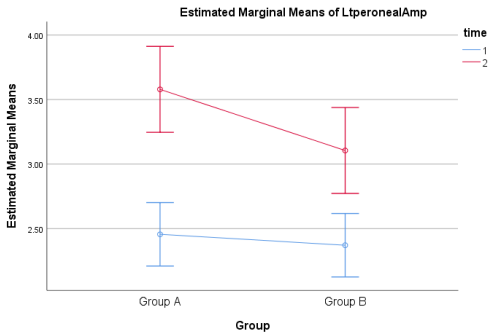


*Figure 4: Estimated marginal means of left peroneal amplitude [mV] of both groups.*

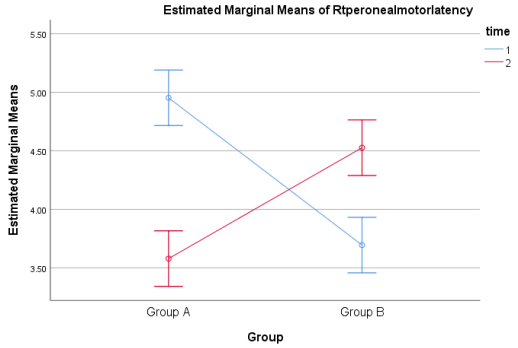


*Figure 5: Estimated marginal means of right peroneal motor latency [m/sec] of both groups.*

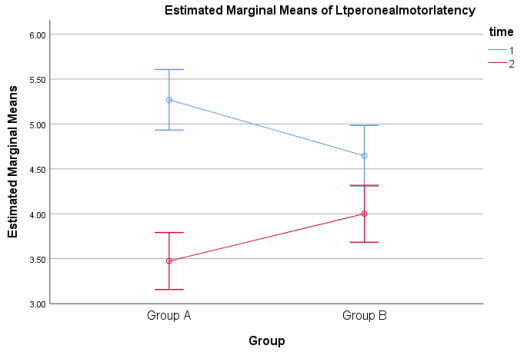


*Figure 6: Estimated marginal means of left peroneal motor latency [m/sec]of both groups.*

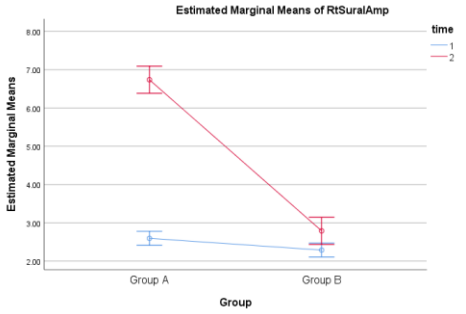


*Figure 7: Estimated marginal means of right sural amplitude [mV] of both groups*

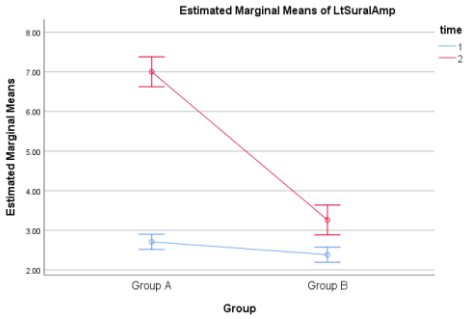


*Figure 8: Estimated marginal means of left sural amplitude [mV] of both groups.*

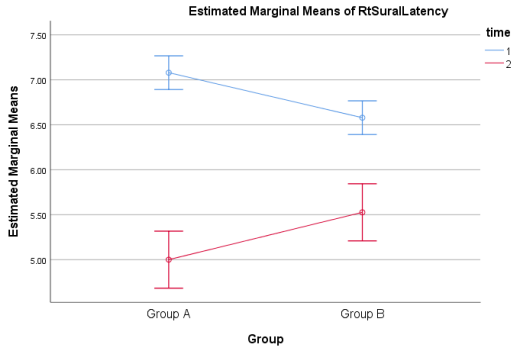


*Figure 9: Estimated marginal means of right sural latency [m/sec] of both groups.*

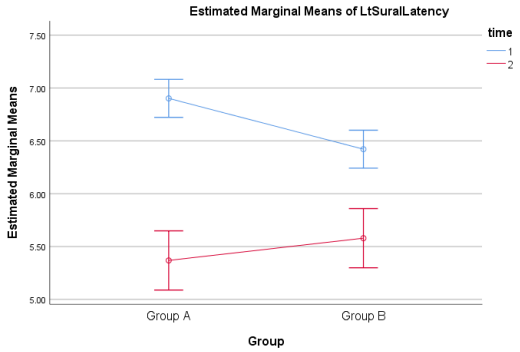


*Figure 10: Estimated marginal means of left sural latency [m/sec] of both groups.*

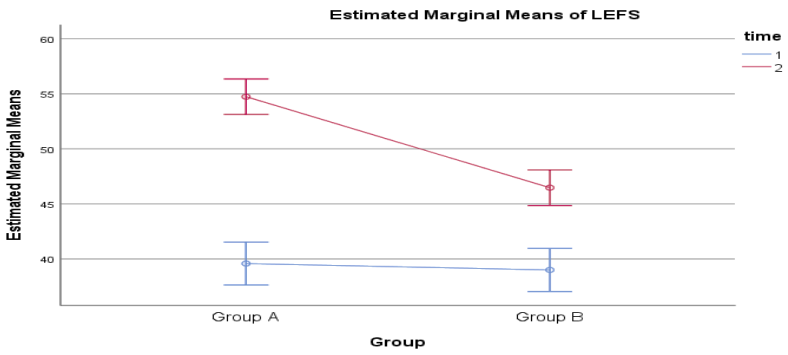


*Figure 11: Estimated marginal means of LEFS of both groups.*

## 4. Discussion:

This study was designed to determine the impact of high-intensity laser exercise versus moderate-intensity aerobic exercise on diabetic polyneuropathy patients.

According to our statistical findings:

For peroneal nerve EMG

There were significant within-group differences in both groups A and B for the post-rehabilitation measurements for all the peroneal nerve EMG measurements. Conversely, no substantial difference was observed between the two groups for any of the measures of the peroneal nerve used for the pre-rehabilitation assessment, except for Rt and Lt peroneal nerve motor latency. There were significant between-group differences in the Rt and Lt peroneal nerve NCVs but no significant between-group differences in amplitude or motor latency.

For a sural, nerve EMG

There were significant within-group differences in both groups A and B for the post-rehabilitation measurements for all the measures of the sural nerve EMG except for the left sural nerve motor latency. Furthermore, there was a substantial difference within both groups for all measures of the sural nerve used for the pre-rehabilitation assessment. There were significant between-group differences in the Rt and Lt sural nerve amplitudes but no significant between-group differences in the sural nerve motor latency.

For the lower extremity functional, scale [LEFS]

There were significant within-group differences in both groups A and B for the post rehabilitation measure for LEFS. On the other hand, there were no significant within-group differences for either group in terms of the LEFS score at the pre-rehabilitation assessment. There were significant between-group differences in LEFS.

This finding is corroborated by Gungormus et al. [2009] **[15],** who discovered that the laser has a relatively long wavelength, is directly absorbed by tissues at a depth of 1–2 cm, and exerts an indirect effect extending up to 5 cm. The potential cause of pain alleviation may be attributed to enhanced microcirculation, elevated ATP synthesis, and the ability to function as an analgesic as well as an anti-inflammatory agent. Funk et al. [1993] **[16]** reported that alternative explanatory variables may stem from enhanced circulation, resulting in increased release of cytokines and growth factors, which induce vasodilation and facilitate the development of new capillaries.

These findings align with those of Prasun et al. [2019] **[17],** who demonstrated that deep tissue lasers effectively alleviate pain among older adults with DPN and enhance their overall QOL. This intervention resulted in a notable improvement in the Timed Up and Go score, reflecting reductions in pain, increased gait speed, and enhanced physical performance. Additionally, the intervention yielded significantly shorter times along with decreased pain, as measured by the Pain Disability Questionnaire, quadruple visual analog scale, and numeric pain scale. Thus, HIL significantly improved the LEFS in our study.

Our findings align with those of Shymaa et al. [2020] **[18]**, who reported that the administration of an HIL at a wavelength of 1064 nm, with a power of 5.00 W and a dosage of 10 J/cm² during the analgesic phase for 6 minutes, in addition to a dosage of 60 J/cm² during the biostimulation phase for ten minutes, applied 3 times weekly over 15 sessions, is superior to TENS at 80 Hz, 50 AMP, and 0.2 ms square pulses for 20 minutes, also 3 times weekly over 15 sessions, in the evaluation of common peroneal motor as well as sural sensory NCS and in the LEFS.

Kujawa et al. [2004] **[19]** reported that utilizing a specific waveform characterized by frequent peaks of elevated amplitude and intervals between them can rapidly induce photochemical as well as photothermic effects in deep tissue,

increasing blood flow, vascular permeability, and cellular metabolism. HILT has been shown to be an analgesic IMPACT for nerve endings; however, no indication of reduced inflammation has been reported **[20, 21].**

This research is further corroborated by Joseph et al. [2007] **[22],** who investigated the long-term management of DPN using high-power laser therapy [HPLT] and concluded that HPLT facilitates nerve regeneration, enhances vasodilation, and promotes neocapillary formation. Deep heating is only one aspect of HPLT, which is safe and almost completely free of adverse effects **[22].**

Dixit et al. [2014] **[23]** examined moderate-intensity aerobic exercise as a fundamental approach to enhancing QOL among subjects with DPN associated with type 2 diabetes. Panteleimon et al. [2021] **[24]** reported that aerobic exercise is the preferred therapeutic activity for individuals with DPN in clinical practice.

## 5. Conclusions:

We can conclude that both high-intensity laser and moderate-intensity aerobic exercise have beneficial effects in favor of high-intensity lasers.

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**Conflict of Interest:** The author declares no conflict of interest.

**Ethical committee:** The research obtained approval from the Ethical Committee of the Faculty of Physical Therapy at Deraya University [DCSR/05024/12].

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