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Effect of Neuromuscular Electrical Stimulation Versus Low-Intensity Laser in Relation to Motor Conduction Velocity of the Neuropathic Common Peroneal Nerve Post Burn

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Abstract

Background : there aredifferent interventions for neuro-rehabilitation in patients with motor dysfunction. Improved motor conduction velocity could enhance functional outcomes and quality of life.

Purpose: This study aimed to find out the impact of Neuromuscular Electrical Stimulation (NMES) versus Low-Intensity laser (LIL)in relation to motor conduction velocity of the neuropathic common peroneal nerve post burn.

Participants:A total of 60 patients, aged between 20 and 35 years, were chosen from the out-clinics of Kasr-El-Aini (Cairo University hospitals) as well as Om-Al-Misrieen hospital. The patients were unfamiliar with the techniques of NMES as well as LIL. They were experiencing burns in the chronic phase after being discharged from the hospital, specifically affecting their lower limbs. The burns covered a percentage of their total body surface area (TBSA) that range from 20% to 30%. The burns were diagnosed early as either second or third-degree burns along with were complicated by peripheral mono-neuropathy, specifically affecting the common peroneal nerve.

Methods: The participants were divided into two groups, labeled as Group A& Group B. Group A consisted of 30 patients who received NMES for a total of 2 months, with each session lasting 20 minutes and occurring three times a week. Group B consisted of 30 patients who received LIL for the same duration and frequency.

Outcome Measures: The Neuropack 2 MEB-7102K was used to objectively measure the motor conduction velocity (MCV) for the common peroneal nerve in meters per second. Measurements were taken prior to initiating the treatment as an initial record and at the completion of the second month of treatment as a final record.

Results: Both groups experienced a substantial improvement in MCV following treatment in comparison to prior to treatment. Group A

exhibited a substantial improvement in the MCV following treatment, in contrast to group B.
conclusion: The utilization of both NMES as well as laser therapy proved to be successful in reducing edema and inflammation, alleviating the compressive ischemic pain, and enhancing nerve function among burned patients, resulting in quick recovery and reintegration into society. However, NMES proved to be more advantageous than the laser.
Key words: Burn; Low intensity laser therapy; Neuromuscular Electrical Stimulation; Neuropathic common peroneal nerve ; Motor conduction velocity.

INTRODUCTION

A burn injury can cause severe damage to the neuromuscular system. Patients frequently attribute weakness or diminished sensation to the overall effects of the burn damage and the process of recovery. Nevertheless, these symptoms could potentially be caused by peripheral neuropathies that arise from the impairment of nerve axons, myelin sheaths, or both (**1).**

Thermal injuries have been found to cause peripheral neuropathies, which primarily damage the nerves located beneath the burned area. Peripheral neuropathies typically occur among patients with burns over 20% of their TBSA **(2).**

Neuromuscular electrical stimulation (NMES) is employed to enhance muscle strength, improve muscle endurance, facilitate tissue repair, reduce pain, regulate edema, and provide functional electrical stimulation. Theories of strength augmentation in NMES are grounded in the overload principle and the recruitment phenomena, whereby NMES enhances and activates the major motor nerves **(3).**

Elevated doses of LILT typically suppress tissue metabolism. Multiple studies have demonstrated the effectiveness of LLLT in treating neuropathic orofacial pain as well as diabetic neuropathy. The impact of LILT on the development of scars has not been assessed in a controlled study. Additionally, the treatment of fibrosis or calcification resulting from hematoma or fat necrosis is not addressed in detail in the existing literature on LILT **(4).**

MATERIALS AND METHODS

Study design and ethics

The study was a randomized control trial. Sixty patients were enrolled from out-clinics of Kasr-El-Aini (Cairo University hospitals) as well as Om-Al-Misrieen hospital**.** The investigation was conducted from October 2023 to January 2024. The subjects were randomly allocated into two groups, labeled as Study Group A as well as Study Group B. The initial study group consisted of 30 patients who received NMES, while the subsequent study group had 30 patients who received LIL. Both groups were allocated 20 minutes every session, three times a week, over a total treatment period of two months. The Physical Therapy Department's Ethical Committee at Cairo University in Egypt gave their stamp of approval to the study **(NO: P.T.REC/012/003584)** and was registered on *Clinicaltrails.gov* with identification number **(NCT06478914).**

Participants: A total of 60 individuals with burn injuries were enrolled. The participants were chosen from the surgical departments of Kasr-El-Ani (Cairo University hospitals) as well as Om-Al-Masrieen hospital. In order to be eligible for the study, the patients needed to have chronic phase burn injuries (occurring after hospitalization) that affected the lower limbs, with the percentage of the TBSA between 20% to 30%. Additionally, their initial diagnosis had to be a second- or third-degree burn exacerbated by peripheral mono-neuropathy that primarily impacts the common peroneal nerve.Individuals who didn't fit the criterion for inclusion weren't included

or if they had life threatening disorders as renal failure or myocardial infarction, skin diseases or

diabetes or varicose veins,pregnant patients or who presented with active malignancy **(5).**

Outcome measures: The Neuropack 2 MEB-7102K was used to objectively assess the MCV of the common peroneal nerve. The design of this device is intended to be both compact and self-contained. The system consists of a primary unit that includes powerful 2-channel amplifiers, a versatile stimulator, a floppy disk drive, a high-resolution thermal array recorder, an advanced electrode junction box with isolation amplifiers, as well as an articulated arm. Additionally, there is an optional cart having a shelf for an optional keyboard as well as a drawer for accessories.

Assessment procedures: The two tests were administered at approximately the same time of day to mitigate the impact of a single variable that could potentially cause minor variations in the required data for each individual subject **(6).**As soon as the subject arrived, they were instructed to lie down on a therapeutic plinth for around five minutes to relax, get used to the area, and rest. The active recording electrode was positioned directly above the primary mass of the EDB muscle, which is situated in the anterolateral region of the proximal midtarsal area. The ground electrode was positioned over the medial side of the foot, whereas the reference electrode was positioned distally over the small toe. The stimulating cathode was positioned 8 cm in front of the active recording electrode during the distal stimulation in order to create a consistent distal latency segment. In the proximal stimulation, the cathode used for stimulation was positioned distally in the lateral region of the popliteal fossa, specifically located just medial to the biceps femoris tendon. The recording electrodes, together with the ground electrode, were saturated with jelly and securely affixed in position using adhesive plaster **(6).**

The impedance of the electrodes for the active channels was verified to be below 5 kiloohms, as well as the process of acquiring data was initiated by clicking the run key on the computer. The stimulus was incrementally raised until the figure (trace) was acquired, at which point the stop key clicked and the cursor was relocated to measure latency.

Measurements were taken using a tape measure to record the segmental lengths between the stimulation locations, which were indicated with a marker pen halfway between the two electrodes. The NCV was determined using the appropriate formula:

$$\text{Conduction velocity} = \frac{L1 - L2}{\text{Distance in (cm)} \times 10}$$

Where: L1 = proximal latency and L2 = Distal latency **(7).**

Treatment procedures:

patient orientation and electrode placement for the NMES: the patient was lying down in a comfortable position with their hips slightly bent and rotated laterally, their knees barely bent (only 10 degrees), and their ankles gently plantar flexed. In the first study group, just one channel of NMES was used, with two electrodes. One electrode was placed on the outer edge of the popliteal fossa (red positive electrode), whereas the second electrode was placed on the outer surface of the fibular head (black negative electrode)**(8).**

The patient was lying down in a relaxed position while the electrodes were placed for the LIL treatment. The laser probe was positioned with no pressure to the lateral border of the popliteal fossa as well as lateral surface of the fibular head, using the continuous mode as well direct contact method. This was done to prevent the patients from experiencing tenderness. The treatment was administered to each region in a systematic manner, with intervals of 1 centimetre. A grid of points, also spaced 1 centimetre apart, was used to cover the whole

surface of the region. Each point in the grid was exposed to radiation for a duration of 90 seconds. This means that in each region, about 10 points were treated, resulting in a total treatment time of 900 seconds, which is equivalent to 15 minutes. The laser applicator was in direct contact with the surface, ensuring that the beam was administered at a 90-degree angle to the spots, thereby achieving optimal penetration. Prior to disengaging the applicator from the contact site, the device was powered off **(5,9)**.

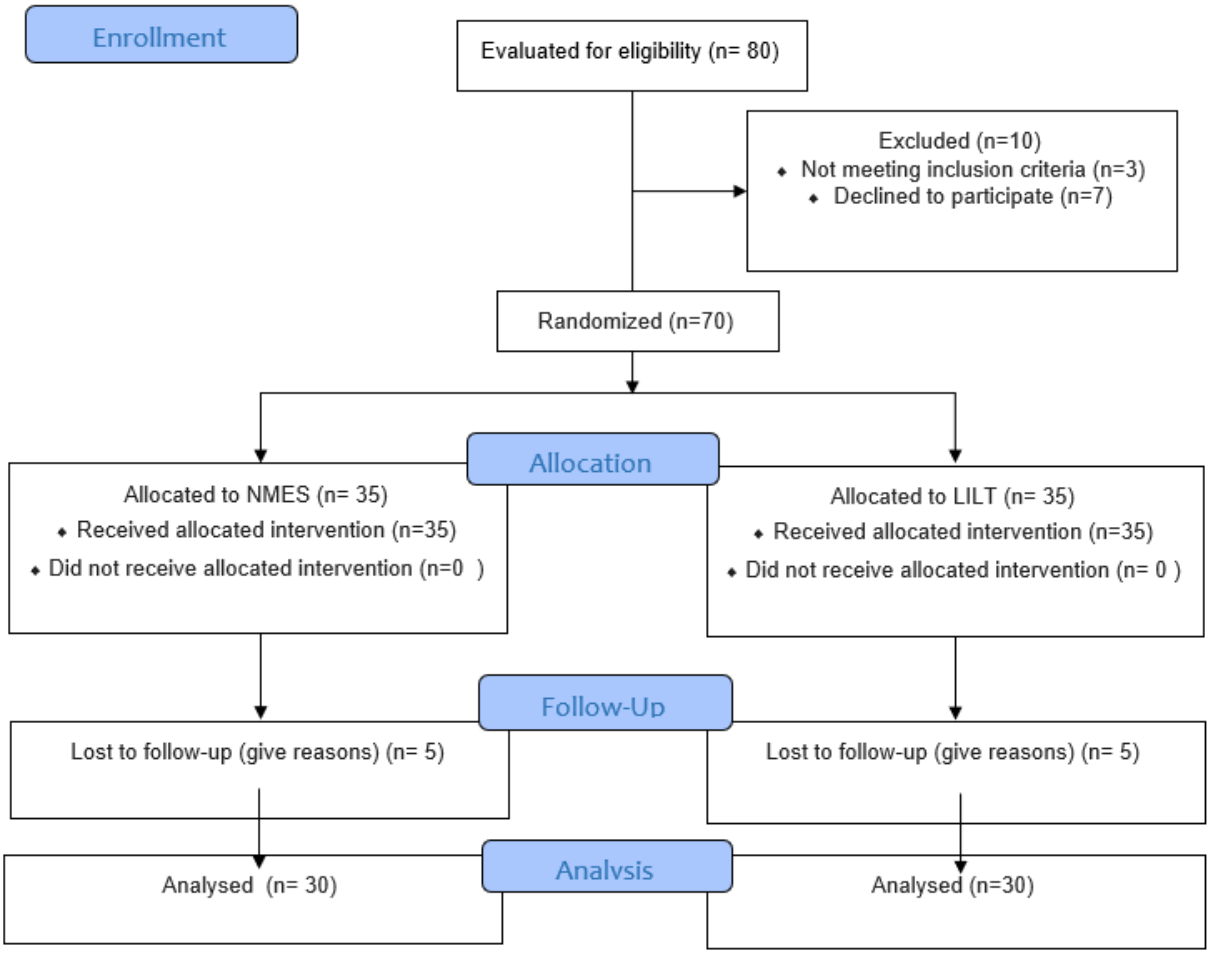

Figure (1): Flow chart of study participants

Statistical analysis

Unpaired t-tests were performed to compare the participant's characteristics among groups. A chi-squared test was used to compare the distribution of sex among groups. The data was assessed for normal distribution via the Shapiro-Wilk test. The Levene's test was used to assess the homogeneity of variances among the groups. unpaired t test was used for comparing the mean values of MCV among groups. A paired t-test was performed to compare prior to and following treatment within each group. The statistical tests were conducted with a predetermined level of significance of $p < 0.05$. The statistical analysis was performed using the SPSS software package, specifically version 25 for Windows, developed by IBM SPSS in Chicago, IL, USA.

RESULTS

***- Subject characteristics*:**

Table (1) presented the participant characteristics of group A & B. There was no substantial difference among groups regardingage as well as sex distribution ($p > 0.05$).

Table 1. Comparison of subject characteristics between group A and B:

	Group A	Group B	MD	t- value	p-value
	Mean±SD	Mean±SD			
Age (years)	28.27 ± 4.66	27.97 ± 3.92	0.3	0.27	0.78
Sex, n (%)					
Females	17 (56.7%)	14 (46.7%)		($\chi^2 = 0.60$)	0.43
Males	13 (43.3%)	16 (53.3%)			

SD, Standard deviation; MD, Mean difference; χ^2, Chi squared value; p value, Probability value

Effect of treatment on MCV:

- Within group comparison:

There was a substantialimprovementin MCV following treatment for group A & B contrasted with that prior to treatment ($p < 0.001$). The percent of change in MCV of group A & B was 13.52 & 3.95% (Table 2, figure 1).

- Between groups comparison:

There was no substantial difference among groups prior to treatment ($p > 0.05$). Comparison among groups following treatment sowed a substantialimprovement in MCV of group A contrasted with that of group B ($p < 0.01$). (Table 2).

Table 2. Mean MCV pre and post treatment of group A and B:

MCV (m/sec)	Pre treatment	Post treatment	MD	% of change	t- value	p value
	Mean ± SD	Mean ± SD				
Group A	32.32 ± 2.57	36.69 ± 2.89	-4.37	13.52	-13.94	0.001
Group B	33.18 ± 1.98	34.49 ± 2.97	-1.31	3.95	-2.87	0.007
MD	-0.86	2..2				
t- value	-1.45	2.89				
	p = 0.15	***p = 0.005***				

SD, standard deviation; MD, mean difference; p-value, probability value

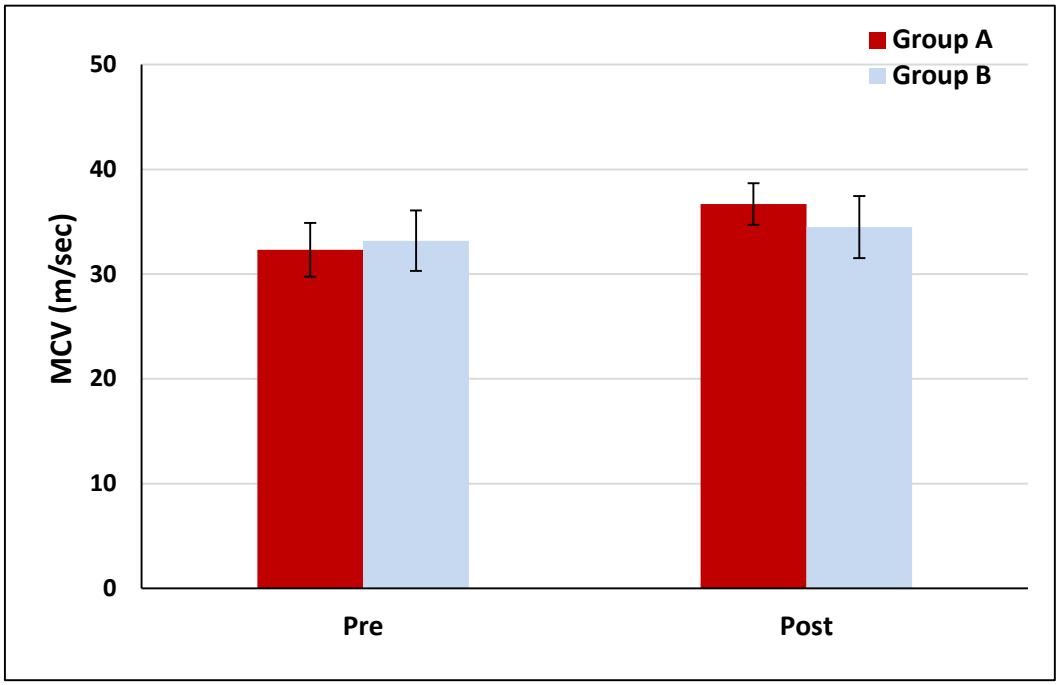

Figure A. Mean MCV pre and post treatment of group A and B.

DISCUSSION:

In the current study, effects of neuromuscular electrical stimulation (NMES) versus low-intensity laser therapy (LILT) on MCV of the neuropathic common peroneal nerve post burn of the post-hospitalization period were investigated.

The patients were allocated at random into two experimental groups, with each group including 30 patients. The 1st experimental group (group A) is the one to which the NMES was implemented, the 2nd experimental group (group B) is the one to which the LIL was implemented.

findings of this study revealedthat there was a substantialimprovement in the MCV of group A contrasted with group B following treatment. This means that both NMES and laser were efficient in enhancing the nerve functions among burned patients. But NMES was more beneficial than the laser.

Regarding nerve function, **Krishnamurthy et al (10)**shown a linear correlation in peripheral vasodilation as well as skin temperature. Specifically, the rise in peripheral vasodilation is associated with a rise in skin temperature, and vice versa. Additionally, there is a linear correlation among skin temperature, subcutaneous temperature, intramuscular temperature, as well as intraneural temperature. Furthermore, NCV is influenced by these temperatures. In fact, there is a direct relationship among NCV along with the degree of peripheral vasodilation. Specifically, NCV raises almost linearly by 2.4 m/s or about five percent for every degree centigrade raise in temperature.

This came in consistence with**Ni et al, (7)** who mentioned that the diagnosis of peripheral neuropathies is aided by nerve conduction studies (NCS) and EMG. Nerve conduction testing evaluates the speed that a nerve conducts an electrical impulse along its axon. While EMG,

evaluates the integrity of a motor unit and allows localization of lesions. Pathological findings usually are related to axonal failure, damage to myelin, a combination of both and pathologies in motor units. Sequential electrophysiological testing can monitor re-innervation and recovery of a motor unit.

Moreover,**Dale et al, (11)** mentioned that john Birch, Outlined the techniques employed to administer electric currentand provided case reports. He applied electrical current for a hand injury of an 18-year-old boy in pain and with contractures. After a few sessions, the boy regained full function of the hand and the pain disappeared. He added that the treatment of chronic constipation by placing a young female patient in an electric chair resulted in an evacuation of bowels in 5 minutes with the application of current. He also described apparent cures in the treatment of gout and other afflictions.

Regarding pain, **Gonnelli et al. (12)** showed that the direct stimulation of the spinal cord's dorsal column could inhibit the spread of pain impulses to the higher perception areas. He experimented with cats and monkeys and found that the pain threshold was increased significantly. Subsequently, Shealy reported the first clinical use of dorsal column stimulation (DCS) in a patient suffering from recurrent metastatic carcinoma of the lung that had intractable pain. Since then, neurosurgeons worldwide have surgically implanted electrodes in the dorsal as well as anterior column to provide stimulation. Recently, Burton has implanted electrodes percutaneously on the spinal cord's dorsal column.

In agreement with NMS, the findings of this investigationwere supported by **Zixuan et al. (13)** showed that electrotherapy in the form of NMS or TENS is able to decrease the metabolic stress and consequently the sympathetic tone leading to increase the blood flow, washing chemical mediators, and decreasing the ischaemic pain, and hence improve muscle spasm, while regional anesthesia with the systemic, epidural or the subarachnoid opioid analgesia will suppress pain via the suppression of the metabolic response in burned patients. NMES, a form of ES that aims to activate peripheral sensory as well as motor nerves, is increasingly being acknowledged as a viable therapy option in neuro-rehabilitation.

In agreement with LLLT, the findings of this investigation were supported by **Depedro et al, (4)**to investigate the impact of Gallium Aluminium Arsenide (Ga-Al-As) laser therapy on pain reduction, A total of 51 patients diagnosed with Tendinitis and Musculoskeletal trigger points were treated with a continuous beam of Ga-Al-As laser (30 mw, 780 nm, 300 Hz) applied directly to the affected area at a dosage of 4 Joules/cm2. Pain assessment was conducted using VAS. Following one day, the pain reduction outcomes from laser treatment demonstrated a statistically substantial decline in pain for both groups.

Finally, according to a study of **Nilsson et al, (5)**evaluated in a placebo-controlled, double-blind, randomised trial how LLLT affected postoperative symptoms following the extraction of lower 3rd molars. In order to examine various factors, researchers divided patients into 2 groups. One group received LLLT prior to, during, and following the extraction of the third molar, whereas the other group did not get any further active laser treatment. This study found no statistically significant improvement in postoperative pain, edoema, trismus, or function impairment following lower 3rdmolar extraction when patients received LLLT treatment.

This study was limited to some factors. An essential one is that patients' psychological status may impact the outcomes depending on their state of mind throughout the procedure. In addition, emotional state of the female patients may affect the results. Finally, possible errors in measuring motor and sensory conduction velocity.

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Conflict of interest
There was no disclosure of any potential conflicts of interest related to this article.

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