

# The Role of Physical Therapy Intervention in the Management of Diabetic Neuropathic Foot Ulcers

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## ABSTRACT

*Diabetic foot ulcers remain a major cause of morbidity across the world, there is a fundamental need to improve the outcomes. Peripheral neuropathy has the greatest risk of foot ulceration. Purpose: The purpose of this study was to investigate the effects of physical therapy intervention in the management of diabetic neuropathic foot ulcers. Subjects: Thirty neuropathic diabetic patients (17 female and 13 male) with age ranging from 35 to 55 years (mean age  $45.1 \pm 6.75$  years). The sample was divided into two groups, the study group (G1) the patients were managed with medical conservative treatment in addition to a specific physical therapy intervention (laser irradiation and specific facilitatory exercises for lower extremities especially for ankle dorsiflexors) control group (GII) was managed with medical conservative treatment. The patients in two groups were assessed before and after the treatment programs, while the treatment program in the study group was applied for 60 minutes, three times per week for twelve weeks. Procedures: Examination included examination of the foot circumference and depth of ulcer, and measurement of foot oedema. Superficial sensation was measured by using the Weinstein Enhanced Sensory Test. Electrodiagnostic tests included nerve conduction study (motor and sensory) were carried out for common peroneal and posterior tibial nerve and the dynamometer was used to evaluate the ankle dorsiflexor muscles' force. Results: The results of this study showed significant improvement in the study group while in the control group, there were no significant changes. Conclusion: Physical therapy plays an important role in the multidisciplinary approach to the patient with Diabetic Neuropathic Foot Ulcers.*

**Keywords:** Diabetes Mellitus, Diabetic Foot, Ulcer, Neuropathy, Physical Therapy.

## INTRODUCTION

**D**iabetic Peripheral Neuropathy is the presence of symptoms or signs of peripheral nerve dysfunction in people with diabetes after exclusion of other causes<sup>12</sup>. It represents 60% of people with diabetes, confers the greatest risk of foot ulceration<sup>8,19</sup>.

Neuropathy causes loss of protective sensation and loss of coordination of muscle groups in the foot and leg, that lead to increase mechanical stresses during ambulation<sup>4,26</sup>.

Increase of plantar pressure plays a crucial role in the development of plantar ulcers in neuropathic diabetic patients<sup>27</sup>. Elevated foot pressure is an important risk factor for foot complication<sup>1,22</sup>. Many studies confirmed a high plantar pressure as a principal factor in the development and non-healing of plantar ulcers in diabetic patients<sup>21</sup>.

For these patients even a trivial foot injury may rapidly lead to ulceration and infection. If left untreated, diabetic ulcers can lead to amputation<sup>16</sup>.

Despite much effort directed toward amputation prevention in the last decade, the incidence of lower extremity amputation in people with diabetes continues to rise<sup>24</sup>. Diabetic foot ulcers should be treated to reduce the number of amputations, maintain health status, and improve quality of life. In fact, many centers that treat diabetic foot ulcers use a multidisciplinary<sup>8,13</sup> team approach., which comprises medical staff, nurses, podiatrists and an orthotist<sup>19</sup>. It should receive care from multidisciplinary foot care team to obtain the best healing results. Healing of diabetic ulcerations is of central importance in any plan for amputation prevention. Significant progress has been accomplished in ulcer healing by improving management of both ischemia and neuropathy in the diabetic foot<sup>14</sup>. However, this efficacy has not translated to positive clinical experience. Thus appropriate techniques for wound care that can reduce amputation rates are an essential prevention strategy<sup>25</sup>. Recently, physical therapy introduced a new dimension in enhancing wound healing. Therefore the purpose of this study was to investigate the efficacy of suggested designed Physical Therapy Intervention in accelerating healing of diabetic foot ulcer and to assist in planning ideal treatment program needed in clinical practice.

## MATERIALS AND METHODS

### Subject

Thirty diabetic sensory-motor neuropathic patients represented the sample of the study. Their age ranged from 35 -55 years. Those patients had type II diabetes mellitus and all were suffering from grade II {Full thickness} diabetic foot ulcer. They had no more than one ulcer. All of them are non smokers and will be under own prescribed

meticulous control of blood glucose, and controlled diet therapy. They had neurological examination which consists of motor system evaluation of (muscle tone, muscle power and reflexes) and sensory system evaluation of deep sensation (joint sense, and vibration sense) and superficial sensation (pain and touch). Exclusion criteria were: significant peripheral vascular disease, significant musculoskeletal disorders in the lower extremities, including injury, fracture, and surgery and rheumatoid arthritis.

### Evaluation procedure

- The measurements of the ulcer surface area were conducted by tracing of the ulcer perimeter and was drawn on sterilized transparency, then the side which faced the ulcer was cleaned by alcohol. The traced transparency film was placed over metric graph paper and number of square millimeter on the metric graph paper with the wound tracing were counted to determine the ulcer surface area. Also the depth of the ulcer was recorded by placing a disposable measuring tape directly into the deepest part of the ulcer. Also the estimation of degree of oedema was done by tap measurement around the center of the ulcer (circumference of the foot).
- Electromyography device, to detect nerve conduction velocity. The device consists of Screen, Bipolar stimulating electrode, Reference electrode, and active recording electrode and computer system. The recording electrodes: The surface disc electrodes were used to record motor potentials and sensory potentials. Ring electrodes were used to record sensory nerve action potential. Stimulating electrodes: Bipolar surface stimulating electrodes were used with poles about 25

mms apart and with the cathode placed distally. Electrical square-wave pulses of 0.2 m/sec. duration were delivered at a rate of 1 Hz and the intensity was increased to be just supramaximal. Ground electrodes: between stimulating electrodes and the recording electrodes.

- Weinstein Enhanced Sensory Test: The device is a manual instrument to measure superficial sensation of the feet. It has an aluminum handle, plastic mounts, stainless steel holding screw and five calibrated enhanced monofilaments which stacked to the handle. Each monofilament tester was used separately and kept perpendicular to the test site, and placed the tip near the skin, slowly the monofilament was pressed down against the site until the monofilament bends; and hold for one second; and then lifted slowly. The greatest size of the monofilament the patient could sense was recorded for each patient.
- Ankle dorsiflexor muscles force was measured by the dynamometer, the patient was in a sitting position at the edge of a plinth. The end piece of dynamometer was fixed on the dorsum surface of the foot which was tested in mid range of ankle joint, proximal to the metatarsophalangeal joints, and the patient was asked to exert his maximum force during the test. Three trials were used and the mean was calculated for data analysis.

### Treatment procedures

Treatment procedures only was done for the patients of the study group, while the patients of the control group received only conservative medical treatment without physical therapy intervention. The program of treatment applied every other day for twelve weeks. The program consisted of four steps:-

\*Step1: local laser irradiation on the ulcer

area, \*Step 2: laser biostimulation for peroneal nerve trunk at the level of the head of fibula, \*Step 3: specific designed physio-therapeutical exercises program and \*Step 4: Instructions and home routine.

**\* Step 1:** local laser irradiation on the ulcer area: Physical therapy sessions included laser irradiation {ASA Laser Therapy Model Bravo Terza Serie, made in Italy, scanner GL.AL.Ar I.R} Time was from 10 to 15 minutes/ session according to surface area and depth of ulcer. The laser irradiation was radiated on ulcer area. The ulcer was cleaned before starting physical therapy session, then covered by dressing directly after the session. This is followed by step 2.

**\* Step 2:** laser biostimulation for peroneal nerve trunk at the level of the head of fibula : hand probe of laser machine to introduce (GL.AL.Ar I.R) was applied to peroneal nerve trunk at the level of head fibula for 15 minutes with frequency 1000 Hz and total energy of 10.5 (j/cm).

**\* Step 3:** specific designed physio-therapeutical exercises program {Patients received specific facilitatory exercises for lower extremities especially for ankle dorsiflexors}. Patients received exercises in form of repeated contraction and synkinetic facilitatory exercise (a specific technique of PNF) for lower extremities directed mainly to ankle muscles from different positions in pattern named {Flexion, Abduction, Internal Rotation} and {Flexion, Adduction, External Rotation}.

**\* Step 4:** the patients were instructed for a home routine that focus on education and regular foot examinations, every patient was advised to wash, dry and examine his/her feet daily and avoid excessive heat and cold, as well as trauma and optimal use of therapeutic footwear. Patients were advised to repeat these exercise at home, warm up, and active ankle

ROM exercises. Subjects wrote the alphabet in the air with each foot by moving the ankle.

Group (II) the control group received medical conservative treatment (in the form of strict diabetic control, ulcer cleaning, and dressing) without physical therapy intervention except their daily routine activities.

### Statistical Analysis

The arithmetic mean and standard deviation of the mean, the student paired t-test (to determine level of significance in one group pre and post treatment), and unpaired t-test between two groups (to determine level of significance between two groups). Level of

significance was assumed at 0.05 for all analysis.

## RESULTS

The mean of total surface area of ulcer before treatment was  $16.2 \pm 3.93 \text{ cm}^2$  while the depth was  $2.42 \pm 0.62 \text{ mm}$  and after treatment both were zero (complete healing). The results of the present study before starting treatment revealed that there were no significant differences in all variables as shown in table (1). Statistical significant improvement of all variable were recorded after twelve weeks of treatment.

**Table (1): Demographic details of the patients participated in this study.**

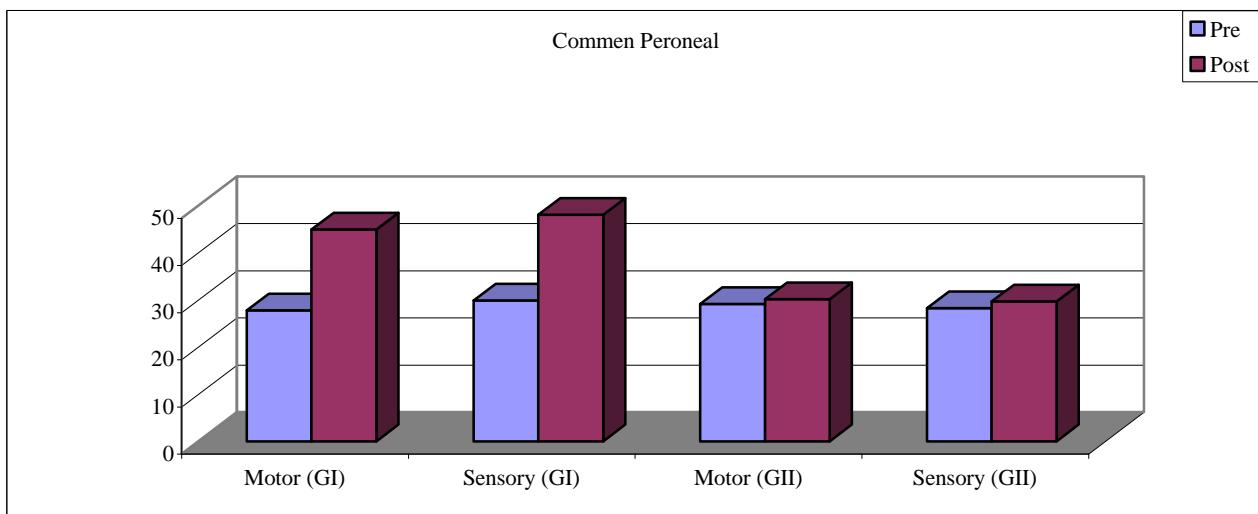
Variable	Study group (GI)	Control group (GII)	t	P
	Mean $\pm$ SD	Mean $\pm$ SD		
Age	$45.93 \pm 7.14$	$44.27 \pm 6.49$	0.6694	0.5087
Duration of Illness	$8.13 \pm 1.92$	$7.67 \pm 2.19$	0.6211	0.5396
Body Mass Index	$26.46 \pm 1.82$	$27.33 \pm 1.67$	1.379	0.1789
Surface Area	$16.2 \pm 3.93$	$15.47 \pm 4.34$	0.485	0.6315
Depth	$2.42 \pm 0.62$	$2.21 \pm 0.54$	0.9778	0.3365
Oedema	$26.12 \pm 3.35$	$25.36 \pm 2.87$	0.6679	0.5098

In regarding to the results shown in table (2) and fig. (1), there was a significant differences in the nerve conduction velocity of common peroneal nerve and posterior tibial

nerve (motor and sensory) in the study group while there was no statistical significant difference in the control group.

**Table (2): Effect of treatment procedures within each group and between the two groups on common peroneal nerve and Posterior tibial nerve.**

Group		Study (I)				Control (II)			
		Mean $\pm$ SD		t-value	P value	Mean $\pm$ SD		t-value	P value
		Pre	Post			Pre	Post		
Common peroneal nerve	Motor	$27.8 \pm 4.18$	$44.93 \pm 5.15$	10.954	0.0001***	$29.13 \pm 2.97$	$30.14 \pm 3.54$	1.357	0.1962
	Sensory	$29.87 \pm 7.56$	$48.07 \pm 9.21$	8.084	0.0001***	$28.26 \pm 8.94$	$29.67 \pm 11.01$	1.993	0.0661
Posterior tibial Nerve	Motor	$30.80 \pm 6.35$	$39.93 \pm 8.54$	5.761	0.0001***	$31.73 \pm 5.11$	$32.20 \pm 5.60$	0.748	0.4668
	Sensory	$22.8 \pm 6.19$	$34.27 \pm 10.24$	8.072	0.0001***	$21.93 \pm 7.13$	$22.87 \pm 8.41$	1.933	0.0737



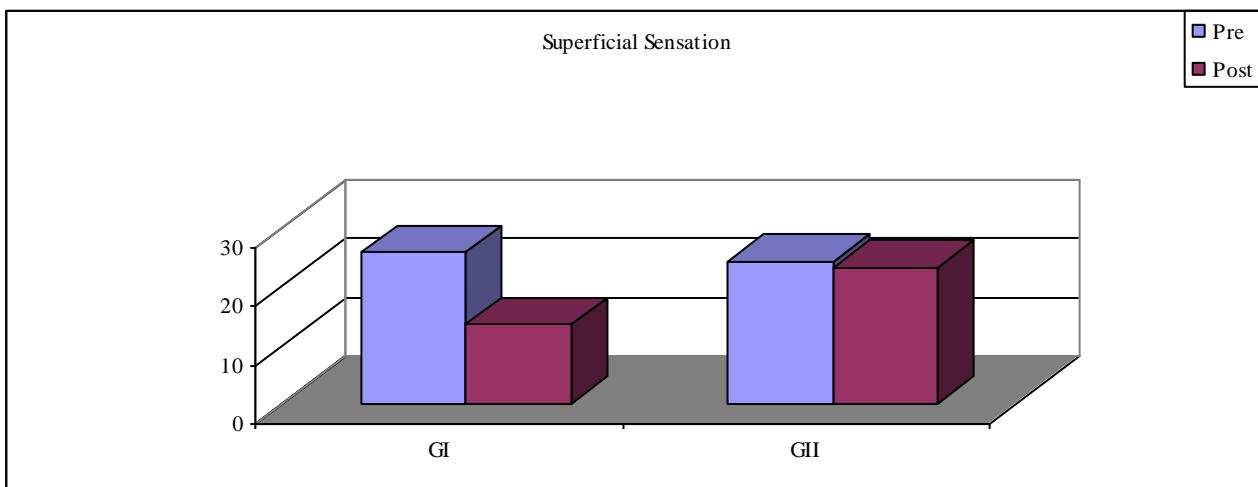
**Fig. (1): Effect of treatment procedures between the two groups on common peroneal nerve.**

In regarding to the results shown in table (3) and fig. (2), there was a significant differences in the superficial sensation in the study group

while there was no statistical significant difference in the control group.

**Table (3): Effect of treatment procedures within each group and between the two groups on superficial sensation.**

Group	Pre	Post	t	P
	Mean $\pm$ SD	Mean $\pm$ SD		
Study (I)	25.67 $\pm$ 6.49	13.40 $\pm$ 7.42	6.853	0.0001***
Control ( II)	24.13 $\pm$ 7.02	23.27 $\pm$ 8.87	1.463	0.1657
t	0.621	3.302		
P	0.539	0.0026**		



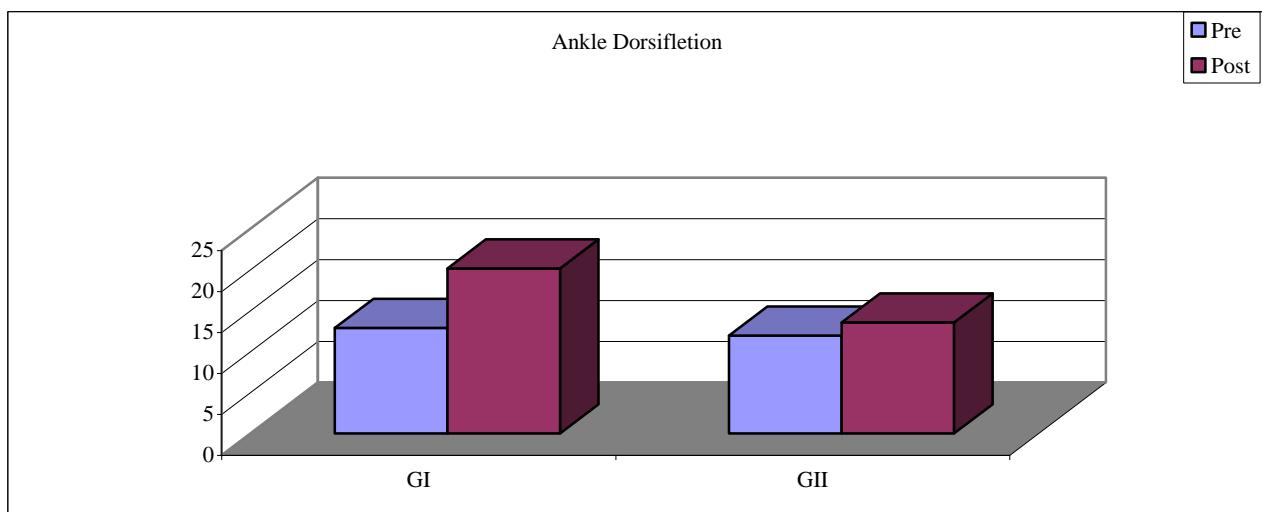
**Fig. (2): Effect of treatment procedures between the two groups on superficial sensation.**

In regarding to the results shown in table (4) and fig. (3), there was a significant differences in ankle dorsiflexion in the study group while

there was no statistical significant difference in the control group.

**Table (4): Effect of treatment procedures within each group and between the two groups on Ankle Dorsiflexion.**

Group	Pre	Post	t	P
	Mean $\pm$ SD	Mean $\pm$ SD		
Study (I)	12.87 $\pm$ 2.26	20.13 $\pm$ 1.12	21.089	0.0001***
Control (II)	11.93 $\pm$ 1.58	13.53 $\pm$ 4.34	1.908	0.077
t	1.31	5.7		
P	0.201	0.0001**		



**Fig. (3): Effect of treatment procedures between the two groups on ankle dorsiflexion.**

#### DISSUCION

Diabetic sensorimotor polyneuropathy (DSP) remains the most common microvascular complication of both type I and type II diabetes, and poses a unique set of management challenges in the prevention of foot complications. The management of DSP is centered on optimal glycemic control, diligent foot care, and pain control as a means of preventing the progression of DSP and reducing the morbidity associated with foot complications<sup>23</sup>.

Neuropathy deprives patients of protective sensation, so that trauma (such as induced by stepping on a sharp object or simply, due to ill-fitting shoes) may be unrecognized, leading to continuing tissue destruction<sup>31,35</sup>. Moreover, it leads to various foot deformities, resulting in abnormal focal pressure distribution on the plantar aspect of the foot. Accordingly, some plantar sites have very high pressures and can easily develop ulcers<sup>31,8</sup>. Ultimately, more than half of chronic foot ulcers become infected<sup>28</sup>. Therefore this study was applied to investigate the effects of physical therapy intervention in

the management of diabetic neuropathic foot ulcers.

The result of this study showed low intensity laser therapy assists in promoting healing of foot ulcers and significantly decreasing ulcer size. This may be attributed to the efficacy of laser to enhance release of growth factors from fibroblasts and stimulate cell proliferation, and increase conversion of fibroblasts into myofibroblast<sup>9</sup>. Moreover laser irradiation produces a sterilizing effect from bacteria that infect the diabetic ulcer, and a significant decrease in ulcer size<sup>32</sup>.

Furthermore it stimulates the release of growth factors and cytokines from monocytes which induce cell proliferation and tissue repair<sup>11</sup>. Histological evaluation in diabetic mice showed that laser irradiation improved wound epithelialization, cellular content, granular tissue formation and collagen deposition in laser treated wounds<sup>30,38</sup>. It is shown while laser irradiation stimulates fibroblast cell proliferation, it mediates suppression or alteration of lymphocytes and immune process, which have a role in persistence of chronic wounds, and this effect may lead to an acceleration of healing<sup>11</sup>. Furthermore; some studies observed a regeneration of micro-circulation in the ulcer and a regeneration of lymphatic circulation<sup>32</sup>.

It is also suggested that laser irradiation induces changes in cellular homeostasis. This coupled with an increase in ATP causes activation of other membrane ion carriers such as sodium, potassium and alters the flow of calcium between mitochondria and cytoplasm<sup>19</sup>. The variation of such parameters is a necessary companion in the control of metabolic and proliferation activity of the cell<sup>11</sup>. Rachkind et al.,<sup>29</sup> reported that, laser significantly improved electrical activity of the impaired nerve, which is keeping with results in this study which shows significant increase

of nerve conduction of both of studied nerves after laser therapy. The symptoms of sensorimotor neuropathy are muscular symptoms: as muscle weakness (not fatigue), atrophy, balance problems, ataxic gait and sensory symptoms (pain, paresthesia, numbness and paralysis, cramping, nighttime falls, antalgic gait)<sup>2</sup>.

Nerve conduction velocity is often used in assessment of the neuropathy. The abnormalities in nerve conduction velocity are correlated to the severity of the disease especially in peroneal nerve conduction and are proportional to the duration of diabetic neuropathy<sup>10</sup>. The problem of nerve damage in diabetes is one of the most neurological and metabolic diseases, which is still over looked by scientists<sup>15</sup>. The nerve damage of poly neuropathy lies in a gray zone, it is equally attributed to both mild segmental demyelination or axonal degeneration<sup>3</sup>.

Laser biostimulation for peroneal nerve trunk as the level of the head of fibula induce nerve tissue regeneration and this result agreed with Laakso et al.,<sup>20</sup> and Hans et al.,<sup>18</sup> who reported that photobiological effects of stimulation and degree of regeneration depend on the wavelength, dose, intensity of the light and the time of exposure<sup>18,20</sup>.

In diabetic neuropathy, there was decreased in tactile and thermal sensitivity, particularly in the heels. This area contains a larger amount of keratin and fat, and receives sensitivity innervation from the sural nerve. This nerve was the first nerve to be damaged during the progression of diabetic neuropathy. Muscle function was decreased, especially with the intrinsic foot muscles, tibialis anterior and triceps surae. In addition, decrease range of motion (an average inversion of 17° and dorsiflexion of 7° was expected among diabetic neuropathy patients). This reduction was due to collagen structure alteration or also

because of loss of strength and trophism of the muscles involved in these joint movements<sup>33</sup>.

The results of this study showed significant improvement in sensory and motor nerves conduction velocity, and power of dorsiflexors, these can be attributed to increasing in nerve regeneration which leads to improvement in superficial sensation and increase in the power of the dorsiflexors and these results agreed with Basford<sup>6</sup> who revealed statistical significant decrease in symptoms of workers suffering from carpal tunnel syndrome and examined by E.M.G. Therefore laser application fastens the regeneration rate and might also prevent nerve degeneration<sup>34</sup>.

Brief Exercise was introduced these may results in an improvement in cutaneous perfusion. The exercise designed to facilitate the ankle dorsiflexors in form of a specific technique of PNF could increase rapidly the available strength of ankle musculatures<sup>37</sup>. This program focused on proprioceptive, strengthening, balance and coordination exercises<sup>17</sup>. Long-term aerobic exercise training can modify the natural history of DPN. Exercises which based on strengthening, aerobic and functional program were feasible and acceptable for people with neuropathy and participation in these exercises may be successful in reducing chronic disablement<sup>5</sup>.

The movements of the subtalar joint are of special interest in the diabetic foot, because any reduction in mobility of this joint may cause an increase in plantar pressures during walking<sup>36</sup>. In the presence of limited joint mobility, the foot is unable to provide its shock-absorbing mechanism and may lose its ability to maintain normal plantar pressures. The presence of limited joint mobility can result in abnormally high intrinsic plantar pressures and lead to plantar ulceration<sup>7</sup>. The results in this study showed improvement in

ankle dorsiflexion ROM, this may be attributed to wound healing, reduced edema, relieved pain and increased strength of ankle dorsiflexors<sup>5,11,23</sup>.

From this study it could be concluded that physical therapy intervention continue to generate new therapies and strategies in the management of diabetic foot ulceration in the fields of wound healing and diabetic foot disease.

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### الملخص العربي

#### دور العلاج الطبيعي التحفيزي في علاج فرحة القدم السكري ذو الاعتلال العصبي

الغرض من هذه الدراسة هو دراسة مدى تأثير دور علاج طبيعي مختار على فرحة القدم السكري ذو الاعتلال العصبي، وقد طبقت هذه الدراسة على ثالثين مريضاً يعانون من فرحة قدم السكري ناجمة عن التهاب الأعصاب الطرفية. تم تقسيمهم إلى مجموعتين وكانت أعمارهم تتراوح من 35 إلى 55 سنة. حيث أن المجموعة الأولى هي المجموعة العلاجية (مجموعة الدراسة) ومتكونة من خمسة عشرة مريضاً وتم تطبيق برنامج علاج طبيعي مختار ، ويتكون هذا البرنامج العلاجي من أربعة خطوات : (1) أشعة الليزر العلاجي على فرحة القدم لمدة من 10 إلى 15 دقيقة ، (2) أشعة الليزر على عصب الشظية لمدة 15 دقيقة ، (3) تقنية خاصة من التسهيل العضلي العصبي ذاتي التحفيز (الانقباض المتكرر) والحركة المحفزة للطرف السفلي وخاصة عضلات شد الكاحل للأمام و (4) الروتين اليومي وإتباع الإرشادات والنصائح لتحقيق الهدف المرجو . بينما عولجت المجموعة الثانية (المجموعة الضابطة) وتشمل خمسة عشرة مريضاً ببرنامج العلاج التحفظي فقط هذا البرنامج الذي تم تطبيقه لمدة اثنى عشر أسبوعاً متتالياً بمعدل ثلاث مرات أسبوعياً. وقد تم تقييم حالة جميع المرضى في المجموعتين عند بداية العلاج ثم في نهاية العلاج ، وتم عمل الفحوصات الإكلينيكية بالإضافة إلى فحص الجهاز العصبي واختبار موضعي لفرحة ، ودرجة الإحساس السطحي في القدمين، كما تم عمل اختبار مدى سرعة توصيل للأعصاب الحركية والحسية، وتم قياس قوة عضلات الكاحل 0 و من نتائج هذه الدراسة وجد انه هناك زيادة ذات دلالة إحصائية ملحوظة و مرتبطة في كل القياسات التي تم دراستها في المجموعة العلاجية (مجموعة الدراسة) ولم يحدث تغيير ذو دلالة إحصائية ملحوظة في المجموعة الضابطة. ومن الدراسة السابقة فإنه يفضل استخدام ذلك البرنامج لعلاج هؤلاء المرضى .