EFFECT OF INTERMITTENT PNEUMATIC COMPRESSION ON NERVE CONDUCTION VELOCITY IN PATIENTS WITH DIABETIC NEUROPATHY

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Abstract

Background: The most prevalent microvascular consequence of diabetes is diabetic polyneuropathy (DPN), which affects over 50% of individuals with type 2 diabetes. It is a prevalent complaint that contributes to morbidity. It has been demonstrated that intermittent pneumatic compression improves this impairment. even though there is currently insufficient research on this topic. **Purpose**: Study the impact of intermittent pneumatic compression on nerve conduction velocity in patients with diabetic polyneuropathy. **Methods**: 40 diabetic neuropathy patients, both male and female, between the ages of 50 and 65, were split into two equal groups at random (Study and Control). Both groups received a traditional program of physical therapy. Furthermore, intermittent pneumatic compression was administered to the study group. For four weeks, the 45–60 minutes treatment sessions were held three times a week. Prior to and following treatment, the Nerve Conduction Velocity (NCV) was used to measure the nerve velocity in the same group and between the two groups. **Results**: There was a statistically significant increase in the nerve conduction velocity after treatment in both groups. this improvement was more statistically and clinically significant in the group of IPC ($p<0.001$). **Conclusion**: Intermittent pneumatic compression adds a valuable effect to the conventional physiotherapy program in improving nerve conduction velocity in diabetic neuropathic patients.

Keywords: Diabetic Peripheral Neuropathy, Intermittent Pneumatic Compression, Nerve Conduction Velocity (NCV).

Introduction

The most prevalent microvascular consequence of diabetes mellitus (DM) and a significant risk factor for complications involving the lower extremities is diabetic neuropathy. The most common pattern of neurological dysfunction is diffuse neuropathy, which manifests clinically as distal symmetrical sensorimotor polyneuropathy[1].

A wide variety of clinical conditions that may manifest as dysfunction of the peripheral nervous system are included in peripheral neuropathy (PN). PN patients frequently exhibit varied degrees of burning, tingling, and/or numbness in their extremities. In 25% of patients, this pain is chronic (lasts longer than three months)[2]. By improving microvascular circulation, the use of Intermittent Pneumatic Compression (IPC) devices can help treat neuropathy[3]. By applying cyclical external compression at specific pressures, frequencies, and durations, intermittent pneumatic compression (IPC) is a popular clinical treatment for enhancing circulation and encouraging ulcer healing[4].

IPC can relieve the symptoms of neuropathy by increasing neuronal flow through several potential pathways. Applying positive pressure on blood arteries causes the release of nitric oxide. Nitric oxide (NO) is thought to have a significant role in treating diabetic patients' neuropathy by controlling blood pressure and maintaining vascular tone[5]. The use of IPC in the treatment of diabetic peripheral polyneuropathy is not studied well in literature, the only available data are only on its use in vascular insufficiency and lymphedema. Although the main cause of diabetic morbidity, including peripheral neuropathy, is the vascular insult. So, we try to fill the literature gap so, the purpose of this study was to investigate the effects of intermittent pneumatic compression on nerve conduction velocity in individuals with PN, as there is currently insufficient research on this topic.

Methods

This randomized controlled trial was performed at the outpatients Clinic of Department of Neurology, Faculty of Medicine, Zagazig University, Egypt in the period between June 2023 and December 2023. Study approval was given by the Ethics Committee at the Faculty of Physical Therapy-Cairo University (P.T.REC/012/005617).

All the patients had grade two moderate diabetic peripheral sensorimotor neuropathy on the neuropathy disability score according to a referral clinical neurophysiological study and grading of neuropathy scale; especially in the lower limbs[6]. Patients included if their age between 50 and 65 years, they were suffering from a typical grade two sensorimotor diabetic peripheral neuropathy according to grading of neuropathy disability score, Body mass index (BMI) till 30 kg/m2, HbA1c between 6.5 and 7.5 %.

Clinically all selected patients suffered from positive neuropathic sensory symptoms as numbness, prickling or stabbing, burning or aching pain predominantly in the toes, feet, and mild distal motor weakness not less than grade 3 group muscle test according to simple neurological sheet assessment, All patients should be able to walk without assistive aid While, patients were excluded, if they had Rheumatoid arthritis, cardiac disorders, deep vein thrombosis (DVT),

retinopathy, scars under their feet, orthopedic or neurological dysfunction affected balance performance, recent lower limbs fracture less than three month, toe amputation. Advanced osteoarthritis of lower limbs, history of recent trauma or accidental injuries, Skin disease, or permanent cardiac pacemaker.

Randomization

Eligible participants (N=40) were randomly and equally divided to two groups (study and control of 20 patients each) using sealed envelope. Both groups received selected physical therapy programs; in addition to that the study group also received intermittent pneumatic compression.

Procedures:

For all patients in both groups, the subsequent evaluations were completed pre and post intervention.

Assessment Procedures:

A. Assessment of amplitude and nerve velocity using Nerve Conduction Velocity Test:

A nerve conduction study (NCS) is a medical diagnostic examination frequently used to assess how well the body's motor and sensory nerves operate[7]. Additionally, the NCV test evaluates nerve dysfunction and injury. also, it aids in the diagnosis of nerve disorders or conditions in which muscles have been impacted by nerve injuries[7]. The motor and sensory conduction investigations were evaluated in accordance with the diabetic neuropathy protocol of the common peroneal, tibial, and sural nerves. It was used to get an unbiased assessment of the amplitude and velocity of nerve conduction[8].

Interventions:

Patients in both groups received the following conventional physiotherapy program which included:

1. Proprioception Exercise:

The activities like progressing to dynamic balance activities was done by walking on the floor, while static balance activities were done by using the balance board. All the patients in two groups started exercises by standing on a level floor surface with one foot in front of the other, heel to toe with arms beside the body. The patient was stood in this position for 30 seconds to 60 seconds with his /her eyes opened then with eye closed[9].

2. Range of motion exercises:

Active free range of motion exercises for ankle and subtalar joints were done. The patients were instructed to perform the exercises with repetition ten times for every movement. Active dorsiflexion and plantar flexion of the metatarso-phalangeal joints, holding each direction for ten sec[10].

3. Foot Care as a home program (advice):

Patients were asked to follow these steps to take care of the feet that are done every day according to protocol: Clean feet daily, using warm-not hot- water and a soap. Dry the feet with a soft towel and carefully especially between toes, inspect feet and toes every day for cuts, blisters, redness, swelling, calluses, or other problems, use a mirror on the floor as it works well for observation of planter aspect of foot, or get help from someone else if patient cannot see the bottoms of feet, moisturize feet with lotion but avoid getting the lotion between toes, each week or when needed, cut toenails to the shape of toes and file the edges with an emery board, always wear light tight shoes to protect feet from injuries. Wear rubber shoes material that fit well and allow toes to move[11].

In the study group

All patients received Intermittent Pneumatic Compression (IPC) in addition to selected P.T program for DPN (Proprioceptive training, active ankle ROM and foot care). Intermittent Pneumatic Compression: patients received 12 sessions every other day for four weeks. Patients were asked to lie in supine positions and cuffs of IPC place around their feet to the upper part of thigh. The applying pressure of IPC was 80 mmHg with slow speed of inflation in all sessions of IPC therapy. After these 12sessions, participants in both groups were examined for all tests of neuropathy, functional status and muscle strength. Place the patient in a suitable comfortable position[12].

Data analysis:

Shapiro-Wilk test was done to test the normality of data distribution. Independent t-test was used to examine the difference between the mean of normal distributed data.Chi square test was used to examine the correlation between non-numerical data. Paired t-test used to compare pre and post numerical data. P value is considered significant if <0.05 at confidence interval 95%18.

Statistical analysis: -

Patients in the control and the IPC group data were revised, coded, and tabulated using the Statistical package for Social Science (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.).

Data was presented and suitable analysis was done according to the type of data obtained for each parameter. The T-independent test was used for quantitative parametric data, for non-parametric data we used the Chi-square test. Qualitative data were represented in percentage and numbers.

Results

Subject:

In present study both groups were matched as regard to age, sex and BMI without any statistically significant differences. In both groups age ranged from 50 to 64 years with mean age of 57 years in study group and 57.3 years in control group.

Table 1: Comparison of Demographic Data between studied groups:

		Study		Control		P-Value
		Mean	SD	Mean	SD	
Age		57	4.8	57.3	4.5	1
BMI		27	1.3	27.8	1.2	0.9
Sex	Female	11	55	14	70	0.3
	Male	9	45	6	30	

Independent T-test; Chi square test

Table 2: Comparison of Nerve conduction velocity between studied groups pre intervention:

		Study		Control		P-Value
		Mean	SD	Mean	SD	
Tibal	R.T	25.8	4.4	25.3	4.1	0.7
	L.T	25.1	3.8	25	3.5	0.9
Sural	R.T	25.9	4.4	25	3.6	0.5
	L.T	25.1	3.8	24.6	3.9	0.7
peroneal	R.T	25.8	4.4	24.9	4.1	0.5
	L.T	25.1	3.8	25.4	3.5	0.8

Independent T-test

Table 3: Comparison of Nerve conduction velocity between studied groups post intervention

		Study		Control		P-Value
		Mean	SD	Mean	SD	
Tibal	R.T	34.9	2.9	28.4	2.5	0.01*
	L.T	32.2	3.4	27.7	3.3	0.01*
Sural	R.T	31.2	4.6	26.9	3.5	0.02*
	L.T	30.9	4.8	26.3	4.4	0.03*
peroneal	R.T	33.7	2.8	28.9	2.3	0.01*
	L.T	33.1	3.2	29.3	1.9	0.01*

Table 4: Comparison of Nerve conduction velocity pre and post intervention in study group

		Pre intervention		Post intervention		P value
		Mean	SD	Mean	SD	
Tibal	R.T	25.8	4.4	34.9	2.9	0.01*
	L.T	25.1	3.8	32.2	3.4	0.01*
Sural	R.T	25.9	4.4	31.2	4.6	0.01*
	L.T	25.1	3.8	30.9	4.8	0.01*
Peroneal	R.T	25.8	4.4	33.7	2.8	0.01*
	L.T	25.1	3.8	33.1	3.2	0.01*

Paired t-test; *significant

Discussion

The purpose of the study was to investigate the effect of intermittent pneumatic compression in addition to the selected physical therapy program on nerve conduction velocity in patients with diabetic polyneuropathy. As regards post intervention sensory and motor nerve conduction study of the study group showed statistically significant increase in nerve conduction amplitude, velocity in all the studied nerves (tibial, sural, and peroneal nerves) in compared to the control group.

When IPC is applied on the foot, the external mechanical pressure causes the emptying of plantar venous plexus and the increase of arteriovenous pressure gradients; the decreased venous pressure induces a transient suspension of the arteriovenous response and reduces peripheral vascular resistance; the shear stress and cyclic strain exerted by external compression from the IPC

system cause the production of endothelial vasodilators[13] Thus, it is helpful to improve vascular function and enhance blood flow. During the inflation and its holding period, the external pressure acts on the muscle tissue and blood vessels, which increase the arteriovenous pressure gradients, and subsequently enhance the instantaneous flow velocity and blood flow. During the deflation and its holding period, the augmented blood flow is mainly attributed to the active vasodilatation and hyperaemic responses after the increase in arteriovenous pressure gradients and ischaemia caused by compression of IPC[14]

The study result is parallel with the result of **Johnson[15]** study in which the author found that diabetic patients who underwent pneumatic compression therapy for 12 weeks showed significant improvements in both sensory and motor NCV compared to a control group. Also, **Lee[16]** study in which Over a 12-month period, diabetic patients who regularly used pneumatic compression therapy experienced slower progression of neuropathy compared to those who did not receive the intervention and NCV decline was significantly less pronounced in the treatment group, suggesting long-term benefits of the therapy. Additionally, **Kumar[17]** study demonstrated improvements in NCV, particularly in motor nerves, alongside reduced edema and improved peripheral circulation after 16-weeks of Pneumatic Compression application.

The improvement in the nerve conduction velocity is due to IPC mimics the natural muscle pump action, promoting venous return and enhancing arterial inflow. Improved blood flow ensures better delivery of oxygen and nutrients to peripheral nerves, which is essential for maintaining nerve health and function. Enhanced microcirculation also helps remove metabolic waste products that can impair nerve function[15]

Also, reduction peripheral edema, common in diabetic patients, can compress nerves and exacerbate neuropathy. IPC promotes lymphatic drainage, reducing edema and alleviating pressure on nerves. This decompression can lead to improved NCV by restoring normal nerve function[15]. Furthermore, improved blood flow and reduced edema create a favorable environment for nerve repair. IPC may stimulate the release of growth factors and cytokines that promote nerve regeneration, leading to structural and functional improvements in peripheral nerves [16].

Moreover, Diabetic neuropathy is often associated with increased oxidative stress and inflammation, which contribute to nerve damage. IPC has been shown to reduce markers of oxidative stress and inflammation, potentially protecting nerves from further damage and improving NCV [17].

Conclusion:

Based on the result of this study, it was concluded that adding intermittent pneumatic compression to traditional physiotherapy has a beneficial effect for increasing NCV in patients with diabetic peripheral neuropathy

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