The Egyptian Journal of Hospital Medicine (January 2024) Vol. 94, Page 108-114

Pneumatic Compression versus Local High-Frequency Vibration Impact on Nerve Conduction and Balance Performance in Diabetic Polyneuropathy

Mohamed Shawky Eliraqi*[1], Hany Ezzat Obaya[1], Hussein Ahmed Abo Saleh[2], Hend Abd El-Monaem Abd El-Monaem[1]

[1]Department of Physical Therapy for Cardiovascular/ Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Egypt

[2]Department of Endocrinology and Diabetes, El Obour General Hospital, Kafr El Sheikh, Egypt

***Corresponding author:** Mohamed Shawky Eliraqi, **Mobile:** (+20) 01090936189, **E-mail:** mohamad.shawky1993@gmail.com

ABSTRACT

Background: One of the most common microvascular complications of diabetes is neuropathy. **Objective:** This study aimed to compare the impact of intermittent pneumatic compression (IPC), high-frequency vibration (HFV), and balance program on nerve conduction velocity (NCV) as well as balance performance in patients with diabetic polyneuropathy. **Patients and methods:** Sixty female patients had lower limb diabetic polyneuropathy (DPN). Their ages ranged from 50 to 60 years. They were randomized into 3 groups of the same number (n=20). The vibration group received plantar, ankle, and cuff HFV. The compression group received lower limbs IPC, and the exercise group received the balance exercise program. The trial was for 12 weeks (3 sessions/week). NCV, Toronto clinical scoring (TCS), and Berg Balance Scale (BBS) were assessed at baseline and after treatment. **Result:** The study demonstrated that all the three groups (HFV, IPC, and exercise) had significant improvement from pre- to post-treatment, with no significant differences among them. The TCS decreased by 17.8%, 11.2%, and 14.8% respectively, in favor of the HFV group. The percentage of improvement of the BBS was 10.8%, 13.04 and 10.6 % respectively for the IPC group. The HFV and IPC groups showed better motor and sensory NCV improvement than the exercise group. **Conclusions:** The local HVF and IPC have almost the same positive impact on NCV and different quality-of-life issues for DPN as relieving pain and paresthesia, improving proprioception, and promoting functional balance better than the exercise group.

Keywords: Functional balance, Intermittent pneumatic compression, Diabetic neuropathy, Motor conduction study, Sensory conduction study, Local vibration therapy.

INTRODUCTION

Diabetic polyneuropathy (DPN) is the most widely prevalent form of neuropathy. DPN in patients with type 2 diabetes affected more than 25%. High blood pressure, cardiovascular diseases, and depression were found to be related with longer periods of diabetes and bad glycemic control [1]. DPN causes pain and somatosensory nervous system lesions. It primarily affects the feet and hands, reducing Schwann cells, axons, and sensory neurons, leading to chronic degenerative diseases [2]. DPN is caused by endo-neural metabolism changes, poor neurotrophic support, and decreased nerve blood flow, potentially due to oxidative stress [3]. DPN is characterized by severe pain, loss of ambulation, and balance problems. It is a risk of falling as well as raising the risk of foot ulceration as well as amputation [4]. DPN patients often have anxiety, depression, and other mental comorbidities, which can worsen pain and treatment response. Sleep disorders and chronic pain are also common, impacting 50% of DPN patients [5]. Vibration therapy has been shown to improve muscle strength, power, proprioception, as well as blood flow beneath the skin. Studies have indicated that vibrating insoles placed on planter feet can improve sensation and balance among patients with DPN [6]. Additionally, vibration therapy can accelerate diabetic foot ulcer recovery [7]. Intermittent pneumatic compression (IPC) is a therapy strategy using whole-leg sleeves to boost blood flow and improve lower limb artery hemodynamics. It boosts arteriovenous pressure gradient and endothelial function [8]. IPC is a common method for enhancing lower extremity peripheral circulation, with efficient dosages ranging from 90 to 120 mmHg in healthy individuals and 120 mmHg for type 2 diabetics [9]. Thus this study aimed to compare the impact of lower limb HFV and IPC therapy on DPN symptoms and patient's quality of life.

PATIENTS AND METHODS

A prospective supervised single-blinded randomized controlled trial (RCT) was conducted at Kafr El-Sheikh General Hospital, Egypt, between May and August 2023. Sixty eligible female patients were selected after clinical assessment. They were diagnosed as bilateral lower limb DPN for at least three months, aged from 50 to 60 years. Their HbA1c ranged between 7% and 9%, and all the patients had significant decreases in the sensory (sural & superficial peroneal) and motor (tibial & deep peroneal) lower limb nerve conduction velocity (from 20 to 30 m/s). All the patients had scored more than twenty on Norfolk QOL-DN and more than eight on the TCS.

Exclusion criteria: Patients with chest diseases, clinical signs of a severe cardiac event, smoking, psychiatric disorders and other types of polyneuropathies (like, alcoholic, hereditary). Patients with lower limb pathology that may interfere with the results like cellulitis, diabetic ulcer, atherosclerosis, or deep venous thrombosis. Using a computer-based randomization program the patients were randomized into three groups (n=20) shown in figure (1). The first group underwent IPC, while the second group received plantar, ankle, and calf HFV. The control group received a balance exercises program and calf/hamstring stretches. The rehabilitation program was performed by the same physiotherapist for all three groups, with blinded evaluation.

Received: 14/09/2023
Accepted: 16/11/2023

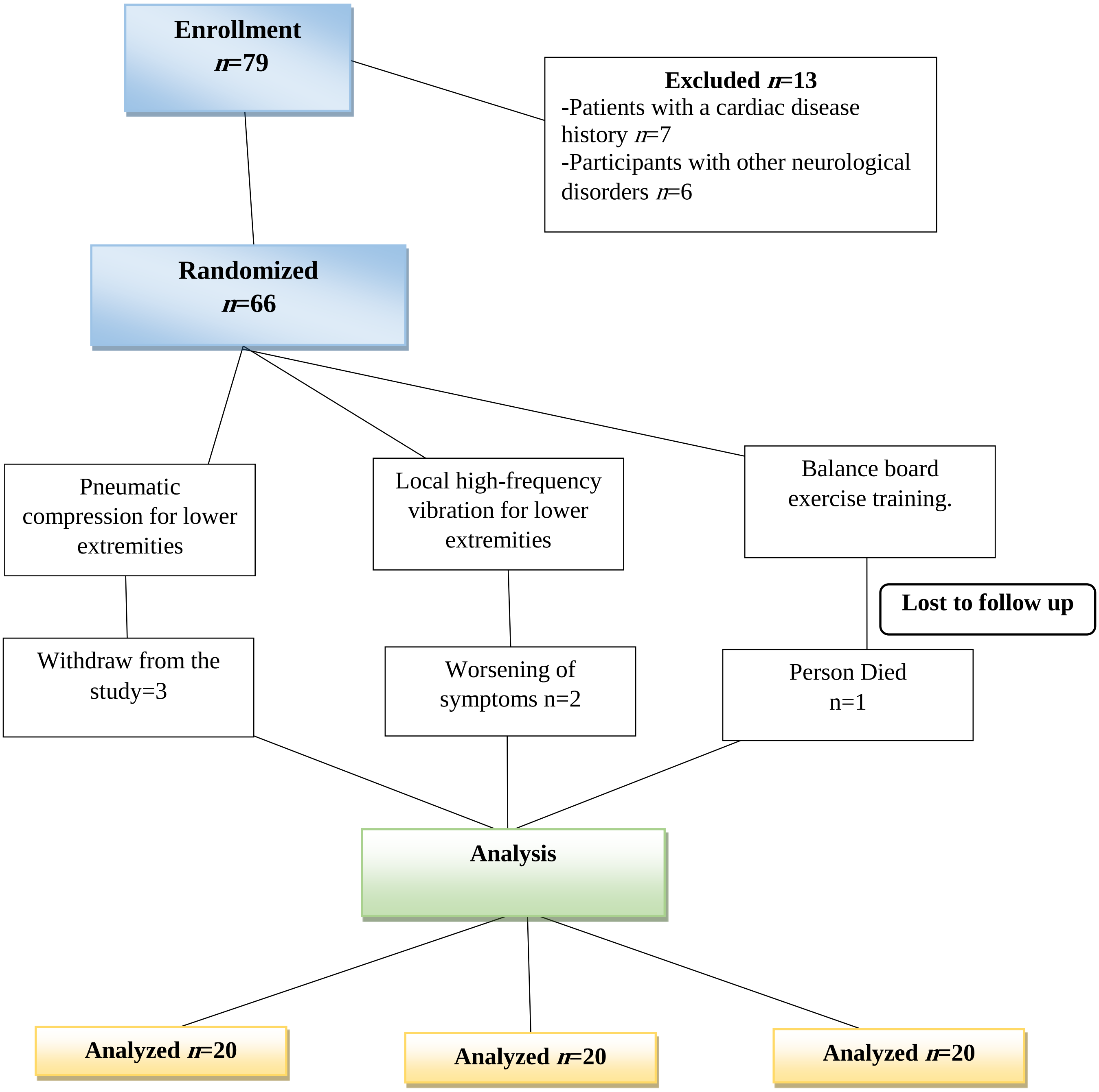

Figure (1): Consort infographic of the study.

Procedures

Intermittent pneumatic compression (IPC) therapy: Patients in the IPC group were given treatment with an IPC device (model: POWER-q 2000, made in Korea) for 12 weeks (3 sessions/week). The patient rested on his back and inflatable cuffs were placed on both lower limbs then the cuff pressure was elevated to 170 mmHg for 15 minutes/session [10].

High-Frequency Vibration (HFV) therapy:

Patients in the HFV group received a local vibration by Phoenix Massage Gun device (model: A2, made in China, intensity: 1500 mA) for both extremities. To begin the treatment, the patient rested on a bed with a cushion under the knees while wearing socks. The vibration was applied on three points: The ankle point: at the middle of the transverse line between medial and lateral malleolus, the planter point: at the cross-section of the transverse line between the head of 1st metatarsal bone to the 5th metatarsal head, and longitudinal line between 1st tarsal webspace to calcaneal process, while the patient was supine, cuff point: at the musculotendinous junction of Achilles tendon while patient in prone position. The duration of vibration was 7 minutes for each point, 3 sessions per week for 12 weeks [11].

The balance program: Patients within the control group received a balance exercise program starting with calf and hamstring stretches for both lower limbs 5 times for each muscle, 30 sec/10 sec stretch/rest followed by a balanced board exercise using a semicircular platform that allow movement in the anterior-posterior as well as medial-lateral axes with a slipping resistant surface, that can offer a protected grip for complete safety during exercise, five minutes exercise duration for each plane, all patients were asked to maintain their balance while the therapist gave several pushes from all directions.

Study outcomes

Electromyography (EMG /NCS): The EMG-DYEMD TRUTRACE, made in the Czech Republic) was utilized to measure sensory and motor nerve conduction velocity in both lower limbs. Data were gathered using a 14-cm antidromic method [12]. The NCV measuring guides involved the following: The patient was positioned in a supine posture, and the electrodes (active (A), reference (R), and ground (G)) were placed in relation to the nerve that was stimulated. Additionally, three stimulation points (S1, S2, and S3) were marked, and F-wave stimulation was detected as described in **Buschbacher and Prahlow**[13].

Motor NCV setting: 5 mV/div sensitivity, 2–3 Hz low-frequency filter, 10 kHz high-frequency filter 5-millisecond-per-division sweep speed. As the medial plantar branch of the tibial nerve innervates the abductor hallucis whereas the peroneal nerve innervates the extensor digitorum brevis**.**

Sensory NCV setting: An average is utilized (between 5 and 10 stimuli). Low-frequency filter of 20 Hz, high-frequency filter of 2 kHz, with a sweep speed 1 msec/division, and a sensitivity of 5 V/division. Locations where the medial along with intermediate dorsal cutaneous branches of the sural as well as superficial peroneal nerves were examined.

Toronto clinical scoring system (TCSS): It is known as the Toronto Clinical Neuropathy Score (TCNS) and is used to measure the prevalence of painful DPN in type II diabetes. It contains three components (symptom, reflex, and sensory test scores) and ranges from 0 to 19 points. The criteria of DPN categories are: 0 to 5 points indicate no DPN, 6 to 8 indicate a mild case, 9 to 11 indicate a moderate case, and twelve to nineteen indicate a severe case [14].

The berg balance scale (BBS): It is a reliable way to estimate physical performance and plans to improve it. It is utilized to evaluate a patient's capability (or incapability) to safely balance throughout a serios of definite tasks without bias. It requires approximately 20 minutes to finish the list of 14 items. Each item is given a score on a five-point scale ranging from 0 to 4. Zero represents the lowermost level of function, while 4 represents the uppermost level [15].

Ethical approval:

The work was authorized by Cairo University's Academic and Ethical Council with the approval number of P.T.REC/012/004301)11/12/2022. The trial protocol was registered in detail on "pactr.samrc.ac.za" with the number of PACTR202309863893315. All participants in this trial signed written consent forms that was given to them. The International Medical Association's rule of ethics for human studies, the Helsinki Declaration, directed this study.

Statistical analysis

All statistical analyses were carried-out utilizing SPSS software version 22. A comparison between the groups' features including age, height, weight, and BMI was performed using ANOVA. MANOVA was utilized to compare nerve conduction velocity (m/s) between all groups. In addition, a paired T-test was utilized to detect the effect of the intervention within every group. Wilcoxon test was employed to evaluate the variations before and after treatment within every group regarding TCSS, and BBS. Kruskall-Wallis test was conducted to compare the three groups pre- and post-intervention regarding these variables. The threshold for significance was determined to be P ≤ 0.05.

RESULTS

An overall of sixty females were equally distributed into three groups at random. Table (1) illustrated no significant difference in the participants' features between all groups as P-value was > 0.05.

Table (1): This table shows the comparison of patients' characteristics among groups IPC, HFV, and exercise groups

	IPC Group (N=20)	HFV Group (N=20)	Exe Group (N=20)	F value	P-value
	$\bar{X}$ ± SD	$\bar{X}$ ± SD	$\bar{X}$ ± SD		
Age (years)	56.6±2.4	56.9±3.3	55.7±3.4	0.860	0.429
Height (cm)	166.05±9.1	164.7±6.7	167.3±9.3	0.456	0.636
Weight (Kg)	90.8±4.9	88.4±4.9	88.1±3.3	2.254	0.114
BMI (kg/m^2)	33.2±3.8	32.9±3.9	31.8±3.5	0.789	0.459

$\bar{X}$: Mean, SD: Standard deviation, p-value: Probability value, *: Significance, BMI: Body Mass Index.

Comparison of NCV between groups indicated no significant differences among all groups concerning the NCV in the right or the left lower extremity neither before nor after the intervention p > 0.05. **The comparison of NCV within groups** revealed a significant improvement after intervention in the IPC, HFV, and exercise groups for the sensory as well as motor nerves for the right lower limb, (Table 2) and for the left lower limb (Table 3). There were almost similar changes in the NCV in the IPC and HFV groups, which were superior to the changes in the exercise group.

Table (2): This table shows the right-side Nerve Conduction Velocity Study (m/s) comparison within and between groups

Right-Side Nerve Conduction Velocity Study (m/s)									
Variables		**IPC Group**		**HFV Group**		**Exe Group**		**Comparison**	
		$\overline{X}$ ± SD		**$\overline{X}$ ± SD**		**$\overline{X}$ ± SD**		**F-value**	**P-value**
Superficial nerve (sensory)	**Pre-Treatment**	26.45±6.16		27.2±5.9		26.9±3.98		0.095	0.909
	Post-Treatment	30.2±6.37		30.5±7.4		28.95±4.9		0.325	0.724
	Percentage of change	**14.2%**		12.1%		7.6%			
	Comparison within Group	**P≤ 0.05***	T=5.00	**P≤ 0.05***	T=4.981	**P≤ 0.05***	T=4.273		
Sural (sensory)	**Pre-Treatment**	25.35±5.77		25.7±5.8		27±3.8		0.555	0.577
	Post-Treatment	29±6		29.2±7.2		30.4±5.1		0.301	0.741
	Percentage of change	**14.4%**		13.6%		12.6%			
	Comparison within Group	**P≤ 0.05***	T=5.101	**P=0.001***	T=4.145	**P≤ 0.05***	T=4.522		
Fibular (motor)	**Pre-Treatment**	26.2±5.6		25.1±4.7		27.7±4.7		1.351	0.267
	Post-Treatment	29.4±5.4		28.8±6.8		29.8±5.6		0.144	0.866
	Percentage of change	12.2%		**14.7%**		7.6%			
	Comparison within Group	**P≤ 0.05***	T=4.584	**P≤ 0.05***	T=4.905	**P=0.014***	T=2.700		
Tibial (motor)	**Pre-Treatment**	26.45±5.5		26.8±6.1		26.6±3.9		0.022	0.978
	Post-Treatment	31±5.5		30.8±7.1		29.2±5.7		0.510	0.603
	Percentage of change	**17.2%**		14.9%		9.8%			
	Comparison within Group	**P=0.003***	T=3.450	**P≤ 0.05***	T=5.252	**P=0.006***	T=3.115		

$\overline{X}$: Mean, SD: Standard deviation, MD: mean difference, p-value: Probability value, *: Significance.

Table (3): The table shows the left-side Nerve Conduction Velocity Study (m/s) comparison within and between groups

Left-Side Nerve Conduction Velocity Study (m/s)									
Variables		**IPC Group**		**HFV Group**		**Exe Group**		**Comparison between groups**	
		$\bar{X}$ **± SD**		$\bar{X}$ **± SD**		$\bar{X}$ **± SD**		**F-value**	**P-value**
Superficial nerve (sensory)	**Pre-Treatment**	26.05±5.7		27.1±4.5		27.9±3.4		0.807	0.451
	Post-Treatment	29.3±5.9		30.2±5.9		30.3±4.6		0.199	0.821
	Percentage of change	**12.5%**		11.4%		8.6%			
	Comparison within Group	P=0.001*	T=3.733	P≤ 0.05*	T=5.008	P≤ 0.05*	T=4.615		
Sural (sensory)	**Pre-Treatment**	25.9±4.4		26.5±5.4		28.6±2.5		2.147	0.126
	Post-Treatment	28.95±5.3		30.2±6.6		30.7±3.9		0.540	0.586
	Percentage of change	11.8%		**13.96%**		7.3%			
	Comparison within Group	P≤ 0.05*	T=5.616	P≤ 0.05*	T=5.885	P=0.002*	T=3.539		
Fibular (motor)	**Pre-Treatment**	25.7±5.4		25.6±6.09		26.6±3.9		0.233	0.793
	Post-Treatment	29.5±6.02		29.60±7.4		28.3±4.98		0.295	0.746
	Percentage of change	14.7%		**15.6%**		6.4%			
	Comparison within Group	P≤ 0.05*	T=4.301	P≤ 0.05*	T=4.386	P=0.003*	T=3.380		
Tibial (motor)	**Pre-Treatment**	26.5±5.6		27.6±5.6		26.95±3.6		0.240	0.788
	Post-Treatment	30.4±6.1		30.3±6.8		29.1±4.9		0.270	0.764
	Percentage of change	**14.7%**		9.8%		7.97%			
	Comparison within Group	P≤ 0.05*	T=699	P=0.001*	T=4.034	P=0.002*	T=3.561		

$\bar{X}$**:** Mean**, SD:** Standard deviation**, MD:** mean difference**, p-value:** Probability value, ***:** Significance.

The outcomes of the study indicated that no significant variation was detected between the three groups either before or after intervention regarding the scores of Toronto clinical scoring, and Berg Balance Scales p > 0.05. **The comparison within groups** revealed a significant impact in the IPC, HFV, and exercise groups after the intervention. Regarding the Toronto clinical scoring, there was a significant reduction post-intervention with a change percentage of **17.8%,** 11.2%, and 14.8%, respectively. The results showed that there was a significant elevation of the score of the BBS post-intervention compared to the pretreatment score with 10.8%, **13.04%,** and 10.6% of change respectively. The best-related outcomes to DPN symptoms were in favor of the IPC group, and the improvement in functional balance was observed in the HFV group (Table 4).

Table (4): Toronto clinical scoring, and Berg Balance Scale comparison within and between groups

Variables		Group A		Group B		Group C		Comparison
		$\bar{X}$ ± SD		$\bar{X}$ ± SD		$\bar{X}$ ± SD		P-value
Toronto clinical scoring system	**Pre-Treatment**	11.8±2.4		11.2±3.04		10.6±2.4		0.168
	Post-Treatment	9.7±2.4		9.95±3.2		9.03±3.5		0.320
	Percentage of change	**17.8%**		11.2%		14.8%		
	Comparison within Group	**P≤ 0.05***	Z=3.652	**P=0.001***	Z=3.275	**P=0.002***	Z=3.148	
Berg Balance Scale	**Pre-Treatment**	28.8±.5		29.9±5.3		31.6±2.1		0.079
	Post-Treatment	31.9±5.8		33.8±5.6		34.95±3.6		0.214
	Percentage of change	10.8%		**13..04%**		10.6%		
	Comparison within Group	**P≤ 0.05***	Z=3.548	**P≤ 0.05***	Z=3.824	**P≤ 0.05***	Z=3.742	

$\bar{X}$**:** Mean**, SD:** Standard deviation**, MD:** mean difference**, p-value:** Probability value, ***:** Significance.

DISCUSSION

The objective of this study was to examine and compare the clinical outcomes of three different therapies-local high-frequency vibration, intermittent pneumatic compression, and a balance exercise program- on sensory and motor nerve conduction velocities, diabetic peripheral neuropathy (DPN) symptoms, and functional balance. A significant improvement has been detected in all three groups from pre- to post-treatment in all parameters. But no significant difference has been detected among the three groups in any of the parameters, either before or after treatment.

According to the results of Toronto clinical scoring system in our study, intermittent pneumatic compression therapy (IPC) proved to be more effective in reducing diabetic peripheral neuropathy (DPN) symptoms by **17.8%**, both HFV and IPC therapies showed almost equal improvement in motor and sensory nerve conduction velocity (NCV) compared to balance exercise. This comes parallel with a **Ren *et al.*** [16] study that noticed when IPC is applied to the foot, external pressure causes the plantar venous plexus to empty and arteriovenous pressure gradients to rise. This temporarily lowered peripheral vascular resistance. This increases blood flow and vascular function, due to active vasodilatation and hyperemic reactions. The results are consistent with the results of **Thorn *et al.*** [17] that insisted on the positive effect of hand intermittent pneumatic compression evoking transitory hypoxic stimuli in distal finger skin microcirculation inducing vasodilation of arterial inflow vessels, in young and older subjects and older subjects with type 2 diabetes mellitus. **Winberg *et al.*** [18] confirmed our findings that intermittent pneumatic compression may be a plausible treatment modality for improving self-reported foot sensation as well as static and dynamic balance control, raising NCV as a sign of improvement.

In our study the results of local high-frequency vibration therapy (HFV) was found to have a more positive impact on improving balance performance, with an increase of **13.04%** in the Berg scale score. Additionally, both HFV and IPC therapies showed almost equal improvement in motor and sensory nerve conduction velocity (NCV) compared to balance exercise. In agreement with our findings, **Onal *et al.*** [19] found that vibratory stimuli applied to the plantar region have high benefits on balance, blood flow, tactile sensation, and most body functions. Local vibration was applied to the plantar region, and immediate (within 5 min) significant improvements in postural stability and fall risk values were detected.

CONCLUSION

All groups showed significant improvement, although IPC appeared to be the most successful in reducing DPN symptoms. On the other hand, HFV appeared more efficient for increasing balance performance in addition to their promoting effect on NCV. Previous studies have shown that IPC can improve peripheral blood supply and HFV can enhance proprioception. Therefore, when both IPC and HFV are incorporated into the DPN treatment strategies, it allows for a better quality of life and delays diabetic neuropathy complications.

Funding: This research received no external funding.
Conflicts of interest: No conflict of interest to.

REFERENCES

1. **Lu Y, Xing P, Cai X *et al.* (2020):** Prevalence and Risk Factors for Diabetic Peripheral Neuropathy in Type 2 Diabetic Patients From 14 Countries: Estimates of the INTERPRET-DD Study. Frontiers in Public Health, 8: 534372. doi: 10.3389/fpubh.2020.534372.
2. **Pang L, Lian X, Liu H *et al.* (2020):** Understanding diabetic neuropathy: focus on oxidative stress. Oxidative Medicine and Cellular Longevity, 20: 1-3.
3. **Metsker O, Magoev K, Yakovlev A *et al.* (2020):** Identification of risk factors for patients with diabetes: diabetic polyneuropathy case study. BMC Medical Informatics and Decision Making, 20 (1): 1-5.
4. **Khan K, Andersen H (2022):** The impact of diabetic neuropathy on activities of daily living, postural balance and risk of falls-a systematic review. Journal of Diabetes Science and Technology, 16 (2): 289-294.
5. **Patel K, Horak H, Tiryaki E (2021):** Diabetic neuropathies. Muscle & Nerve, 63 (1): 22-30.
6. **Nadi M, Bambaeichi E, Marandi S (2019):** Comparison of the effect of two therapeutic exercises on the inflammatory and physiological conditions and complications of diabetic neuropathy in female patients. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 12: 1493-501.
7. **Kang G, Zahiri M, Lepow B *et al.* (2019):** The effect of daily use of plantar mechanical stimulation through micro-mobile foot compression device installed in shoe insoles on vibration perception, gait, and balance in people with diabetic peripheral neuropathy. Journal of Diabetes Science and Technology, 13 (5): 847-56.
8. **Martínez-Guardado I, Rojas-Valverde D, Gutiérrez-Vargas R *et al.* (2020):** Intermittent pneumatic compression, and cold-water immersion effects on physiological and perceptual recovery during the multi-sports international championship. Journal of Functional Morphology and Kinesiology, 5 (3): 45. doi: 10.3390/jfmk5030045
9. **Ren W, Duan Y, Jan Y *et al.* (2022):** Effect of intermittent pneumatic compression with different inflation pressures on the distal microvascular responses of the foot in people with type 2 diabetes mellitus. International Wound Journal, 19 (5): 968-77.
10. **Salek S, Bahrpeyma F, Mohajeri-Tehran M *et al.* (2015):** Determining the effect of intermittent pneumatic compression method on improvement of balance, and Valk and Michigan neuropathy questionnaires in patients with type 2 diabetes mellitus. Iranian Journal of Diabetes and Metabolism, 14 (1): 15-26.
11. **Sabziparvar M, Naghdi S, Ansari N *et al.* (2021):** Local plantar vibration for the treatment of diabetic neuropathy: a case report. Journal of Diabetes & Metabolic Disorders, 20: 2115-9.
12. **Misra U, Kalita J (2019):** Clinical neurophysiology: nerve conduction, electromyography and evoked potentials. 4the Edi., Elsevier Health Sciences. https://shop.elsevier.com/books/clinical-neurophysiology/misra/978-81-312-5815-6
13. **Buschbacher R, Prahlow N (2006):** Manual of nerve conduction studies. Demos Medical, Publishing. http://www.tabeae.org/tabeaebooks/Mnul_of_Nrv_Cndctn_Stds.pdf
14. **Yang Z, Chen R, Zhang Y *et al.* (2018):** Scoring systems to screen for diabetic peripheral neuropathy. The Cochrane Database of Systematic Reviews, 18 (7): CD010974. doi: 10.1002/ 14651858.CD010974.pub2
15. **Pelicioni P, Waters D, Still A *et al.* (2022):** A pilot investigation of reliability and validity of balance and gait assessments using telehealth with healthy older adults. Experimental Gerontology, 162: 111747. doi: 10.1016/j.exger.2022.111747.
16. **Ren W, Duan Y, Jan Y *et al.* (2022):** Effect of intermittent pneumatic compression with different inflation pressures on the distal microvascular responses of the foot in people with type 2 diabetes mellitus. International Wound Journal, 19 (5): 968-77.
17. **Thorn C, Adio A, Fox R *et al.* (2021):** Intermittent compression induces transitory hypoxic stimuli, upstream vasodilation, and enhanced perfusion of skin capillaries, independent of age and diabetes. Journal of Applied Physiology, 130 (4): 1072-84.
18. **Winberg T, Hedge E, Peterson S *et al.* (2021):** Influence of intermittent pneumatic compression on foot sensation and balance control in chemotherapy-induced peripheral neuropathy patients. Clinical Biomechanics, 90: 105512. doi: 10.1016/j.clinbiomech.2021. 105512.
19. **Önal B, Karaca G, Sertel M (2020):** Immediate effects of plantar vibration on fall risk and postural stability in stroke patients: a randomized controlled trial. Journal of Stroke and Cerebrovascular Diseases, 29 (12): 105324. doi: 10.1016/j.jstrokecerebrovasdis.2020.105324.