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Effect of strengthening exercise versus intermittent pneumatic compression device to calf muscle on Blood flow in patients with varicose Veins.

Hany Farid Eid Morsy Elsisi[1], Tarek Hanafy Mahmoud[2], Zahra Mohamed Hassan Serry[1], Awny Fouad Rahmy[1] and Naser Mohamed Mohamed Osman[3].

[1]Department of physical therapy for cardiovascular /Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, **Egypt**.
[2]Department of physical therapy for internal medicine, chest and cardiology Faculty of physical therapy, Deraya University, **Egypt**.
[3]Department of Radiology, Faculty of Medicine, Minia University, **Egypt**.

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***Correspondence:** amr_amz_9@yahoo.com **Accepted: 0**9 Mar. 2019 **Published online: 29** June 2019

Varicose veins are not only a cosmetic annoyance; they can lead to complications that result in loss of time from work. Treatment has improved to reduce recovery time and complications. Purpose of the study was to compare between the effects of intermittent and exercise pneumatic compression on maximal blood flow velocity, mean blood flow velocity and refilling time in varicose veins patients. Fifty patients 23 men and 27 women patients were complained from symptomatic varicose veins. Their ages ranged between 35 to 55 years old, with BMI from 30 to 34.9 kg/m^2. Participants were randomly assigned into two groups equal in number (25). Patients in both groups received a physiotherapy program that consisted of lower extremity exercises, which included gluteal and quadriceps isometric exercises, active hip and knee flexion/extension, ankle dorsiflexion/ plantar flexion, and straight leg rising for 12 weeks. Group (A) was consisted of 25 patients who performed intermittent pneumatic compression device. Group (B) was consisted of 25 patients who were performed tip-toe strengthening exercise, ergometer exercise, with elastic compression stocking. Blood flow was measured by duplex for all patients in both groups before and after treatment program. Results of this study indicated that there were statistical significant improvements of the maximum blood flow, mean blood flow; and refilling time in favor of IPC more than exercise.IPC have beneficial effects on the maximal blood flow velocity, mean blood flow velocity and refilling time more than exercises with elastic compression stocking in varicose veins patients.

Keywords: Varicose vein intermittent compression, exercise, blood flow, mid-thigh stocking

INTRODUCTION

Varicose veins are a common progressive medical condition with widely ranging estimates of prevalence that will steadily worsen (Wright and Fitridge, 2013).
The veins become dilated (greater than 3 mm) with twisting and bulging due to weakness of their walls or valves, which usually occurs in the superficial veins of the lower extremities (Fitridge and Thompson , 2011).
Half of the adult population has the stigmata of minor venous disease, and about 25% of the population has lower extremity varicose veins (Rab et al., 2003).

Intermittent pneumatic compression enhanced the blood flow of the treated area through

stimulation of endothelial cell production of nitric oxide. IPC increases the velocity of blood flow and creates shear stress on the walls of blood vessels, which is the probable physiologic mechanism for enhanced nitric oxide production. Increased nitric oxide production also inhibits platelet aggregation and neutrophil adherence, both of which play important roles in the creation of secondary hypoxic injury. Nitric oxide is also a neurotransmitter that can influence vascular tone, thereby increasing blood flow (Capps, 2009).

The muscular pumps of the lower limb include those of the foot, calf, and thigh. Among these, the calf muscle pump is the most important as it the most efficient, has the largest capacitance and generates the highest pressures (200 mm of mercury during muscular contraction). The normal limb has a calf volume ranging from 1500 to 3000 cc, a venous volume of 100 to 150 cc, and ejects over 40% to 60% of the venous volume with a single contraction (Hosoi et al., 2002).

When exercise ceases, the veins slowly fill the capillary bed, causing a slow return to the resting venous pressure. Although the thigh vein are surrounded by muscle, the contribution of thigh muscle contraction to venous return is minimal compared with the calf muscle pump. The planter venous plexus is compressed during ambulation and this pumping action is thought to prime the calf pump. Although the interaction between the various leg pump is not fully understood, all work with competent the valve function to return venous blood from the distal to proximal extremity (Meissner et al, 2007).

Compression of the leg is the mainstay of the therapy in patients who have chronic venous insufficiency (CVI) and is based on the understanding that gradient compression helps to relieve symptoms and to improve venous function. Compression bandages were used by the Greeks and Romans in the treatment of CVI. Despite the fact that it is successful in greater than 95 % of patients when patients are compression

Stocking is largely unknown (Arcelus et al., 2001).

So, the current study carried out to compare between the effect of intermittent pneumatic compression and ergometer exercise, tip-toe strengthening exercise with elastic compression stocking effects on the maximal blood flow velocity, mean blood flow velocity and refilling time more than exercise in varicose veins patients.

MATERIALS AND METHODS

Subjects:

Fifty patients 23 men and 27 women Their age ranged was from 35 to 55 years old within the mean age for group A (43.88 ±6.73) and for group B (44.52 ±6.23) with bilateral varicose veins of the lower limb participated in this study. BMI from 30 to 34.9 kg/m^2. group A mean of BMI (32.59±1.35) while the mean for group b was (32.93±1.004) .Patients were enrolled in the study if they had a symptomatic varicose vein (clinical severity class C2 according to the CEAP classification, a comprehensive classification system) of the lower limb (pain, soreness, burning, aching, throbbing, heavy legs, cramping, muscle fatigue, and/or night cramps) over a period of at least six months**.**

All patients medically examined and diagnosed by the physicians of the Samaloute central hospital and Samaloute medical insurance outpatient clinic. All patients were pregnant or breastfeeding, had any local leg condition in which sleeves will interfere, such as dermatitis, vein ligation, gangrene, or recent skin graft, severe leg arteriosclerosis or other ischemic vascular disease, massive leg edema or pulmonary edema from congestive heart failure, suspecting existing or previous venous thromboembolism and extreme leg deformity or size, Patients who had medical disorder such as diabetes have been excluded (Griffin et al., 2007).

All patients signed on an informed consent before starting Program, and the study was approved by the ethical committee of Faculty of physical therapy Cairo University number : P.T REC/012/001568 and conducted in at of physical Therapy Department at samalout Healthy Insurance outpatients Clinic in Minia Government Egypt from July 2017 to April 2018.

All patients were divided into two groups randomly that were equal in number, Group (A) Include twenty five patients who performed intermittent pneumatic compression device. Group (B) Include twenty five patients who had been performed exercise program in the form Tip toes exercise and ergometer exercise. Patients had wear open-toe elastic compression stocking at home. (Care medically stocking. Healthy co. 34 – 46mm hg.)

Evaluation procedures:

Each patient in both groups passed through the following steps of measurements by physician and physical therapist. The parameters recorded at the beginning and the end of the practical study period three months (12 weeks):

Ultrasound and Color Duplex Doppler Machine.

To examine the venous system of the lower extremities of the patients we used duplex ultrasound in order to measure the maximum and mean venous blood velocities in centimeters per second (cm/sec) and the refilling time in seconds.to

all patients in both groups before and after three months (12 weeks) of treatment. All measurements were performed in a similar fashion at the same time of the day for both groups to reduce variability. Venous blood velocity was measured by ultrasonography imaging performed by the same radiologist. Each subject was placed in the supine position for a minimum of five minutes before the evaluation and baseline venous velocities were recorded in cm/sec. Maximal and mean venous blood velocities were obtained from the common femoral vein cephalad to the sapheno-femoral junction, and the refilling time was also measured. The angle of insonation of the ultrasound scan beam with the vein was 60 degrees (Coleridge et al., 2006).

Weight and Height scale (Anthropometric measurements):

Patients' physical characteristics as weight [kg] and height [m]using weight and height scale and body mass index [BMI] (kg/ m^2) were calculated. Assessment done in accordance with standardized anthropometric protocol described in using the following formula: body mass index = weight (kg) / (height (m)) ^{2} (Jae et al., 2008).

Patients in both groups received a physiotherapy program that consisted of lower extremity exercises, which included gluteal and quadriceps isometric exercises, active hip and knee flexion/extension, ankle dorsiflexion/ plantar flexion, and straight leg raising. The patients were instructed to perform ten repetitions of each exercise three times a day, five times per week for three months (Gucuk et al., 2001).

Patients in group A include performed intermittent pneumatic compression device (Wonjin power Q1000 Korean device). Both lower extremities were treated for thirty minutes daily, three days a week for three months. The device had four chambers which inflated sequentially. It was adjusted to apply a pressure of 65, 55, and 45 mmHg respectably in a distal to proximal direction for 15 seconds followed by 2.4 seconds of non-compression to allow venous refilling. (Gucuk et al., 2001).

Patients in group B were performed tip toe exercise for six minutes (with five minutes rest between the consecutive sets)

(Sabrive et al., 2017). Then instructed to perform ergometer exercise after five minutes rest between the two exercises standard 6.5 resistance pedal ergometer for calf muscle strengthening and endurance for calf muscle strengthening and endurance "Determined by the maximal number of planter flexion performed against a fixed 6.5 Kg resistance during six minutes". (Kan and Delis 2001).

Patients had wear Open-toe elastic compression stocking. (Care medically stocking. Healthy co. 34 – 46mm hg.)

Exercises prescription

The patients of both groups were started exercise session in the form of stretching exercise for lower limb mainly calf muscle for five minute as a warming up for 5 min, Patients in group A were performed intermittent pneumatic compression for thirty minutes. Patients in group B were performed tip toe exercise. Patients were initiated the exercise training by standing in an upright with the balls of the feet on the balls of the feet on the edge of step 5cm high. The patients were instructed to slowly lower your heels to the floor, and then raise them up as far as possible. During the exercise, all subjects were advised to hold a side rail to avoid balance disturbance, Before commencing the exercise program, patients were assessed individually to determine the maximum number of tip-toe exercise that they can performs during the six minutes, During first six weeks, patients were asked to conduct each session by performing three sets of repetitions using half of their maximum number of tip-toe exercise (with five-minutes rest between the consecutive sets, each set followed by two and half minutes of rest), During the second six weeks, the patients were guided to increase the number of the tip-toe exercise to maximum number that they were able perform at the initial pre-training test, using also the three repetitions sets of exercise training for both lower limbs, three times per week for six weeks (Ashraf .A.M. et al., 2013). Then patients had five minutes rest and after that were started ergometer exercise, the patients were asked to perform entailed active planter flexion for sex minutes using standardized 6.5 Kg resisted pedal ergometer. Patients were asked to set on an examination couch with their knee in slight flexion resting on a pillow and their heel firmly placed on the backrest of the ergometer pedal, Before commencing the exercise program, Patients were assessed individually to determine the maximum number of flexion during the six minutes at rate of one flexion per second. In the first six weeks, each training session had been conducted by half of the maximum number of flexion reached at the base line, and then increased up to 360 flexion next six weeks, In each session patients were completed three sets of flexion of six minutes for both feet, each at rate of one flexion per second (with five-minutes rest were allowed between consecutive sets, each set followed by one minutes of rest) The

exercise had been conducted the three repetitions sets of exercise training for each limb(six sets for both lower limbs), three times per week for twelve weeks. (Kan and Delis, 2001).

Patients had wear Open-toe elastic compression stocking at home. The patients of both groups were end exercise session same as warming up stretching exercise for lower limb mainly calf muscle for five minute. Both lower extremities were treated for thirty minutes daily, three days a week for three months (twelve weeks) for both groups.

Statistical analysis:-

Results: Data obtained from both groups regarding maximum blood flow velocity, mean blood flow velocity and refilling time were statistically analyzed and compared. Comparison between variables in the two groups was performed using paired t test. Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. P value ≤ 0.05 was considered significant.

RESULTS

The mean values of age, weight, height and BMI in group A were 43.88 ±6.73 yrs, 84.95 ±8.77 kg,1.61 ±0.07 m and 32.59 ±1.35 kg/m2, respectively. While group B 44.52 ±6.23 yrs, 83.22±8.28 kg, 1.59±0.06 m and 32.93 ±1.004 kg/m2, respectively. There was no statistical significant difference between the two groups as regard age (t= -0.35; p= 0.73), weight (t= 0.72; p= 0.48), height (t= 1.32; p=0.19) and BMI (t= 1.009; p= 0.32) (Table1).

In group (A), after treatment program, there was statistical significant improvement of blood flow measurements. The maximal blood flow velocity improvement was 51.75%, mean blood flow velocity improvement was 69.64%, refilling time improvement was 23.14%.

Also group (B) after treatment program, there was statistical significant improvement of blood flow measurements. Improvement on the maximal blood flow velocity was 22.86%, mean blood flow improvement was 33.33%, refilling time improvement was 12.89%.

The mean score for maximal blood flow velocity after the treatment program was 18.59 ± 2.58 cm/sec for group (A) and it was 14.94 ± 1.85 cm/sec for group (B). The result revealed significant differences between both groups in favor of group (A). (Intermittent Pneumatic Compression Device).

The mean score for mean blood flow velocity after the treatment program was 11.79 ± 1.82 cm/sec for group (A) and it was 9.08 ± 1.04 cm/sec for group (B). The result revealed significant differences between both groups in favor of group (A). (Intermittent Pneumatic Compression Device).

The mean score for refilling time after the treatment program was 23.77 ± 2.42 sec for group (A) and it was 27.02 ± 1.67 sec for group (B). The result revealed significant differences between both groups in favor of group (A). (Intermittent Pneumatic Compression Device).

Table 1: General characteristics of the two studied groups.

Variables	Intermittent pneumatic compression group	Exercise group	Comparison			Significance
	Mean ± S.D	Mean ± S.D	MD	t-value	p-value	
Age (Years)	43.88 ±6.73	44.52 ±6.23	-0.64	0.35	0.73	N.S
Weight	84.95 ±8.77	83.22±8.28	1.73	0.72	0.48	N.S
Height	1.61±0.07	1.59±0.06	0.02	1.32	0.19	N.S
BMI	32.59±1.35	32.93±1.004	-1.34	1.009	0.32	N.S

Data are expressed as mean ± SD. NS= p> 0.05= not significant

Distribution of male and female in both groups: Table (2)

Table (2): Intermittent pneumatic compression group A (right lower limb): fig (1)

	Male	Female	Total
Intermittent pneumatic compression group	11	14	25
Exercise group	12	13	25
Total	23	27	50

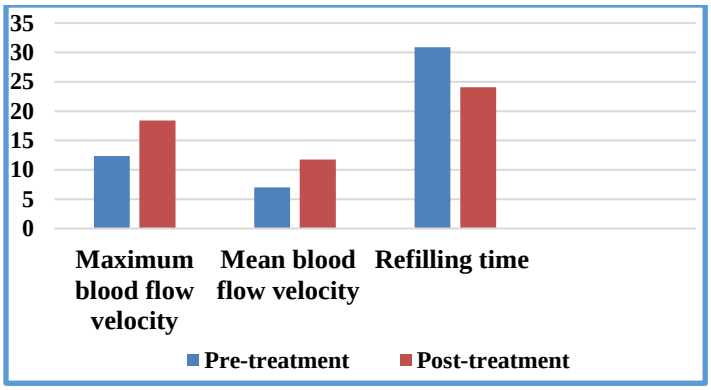

Figure (1) Mean values of pretreatment and post treatment data of right lower limb in intermittent pneumatic compression group.

Intermittent pneumatic compression group (left lower limb): fig (2)

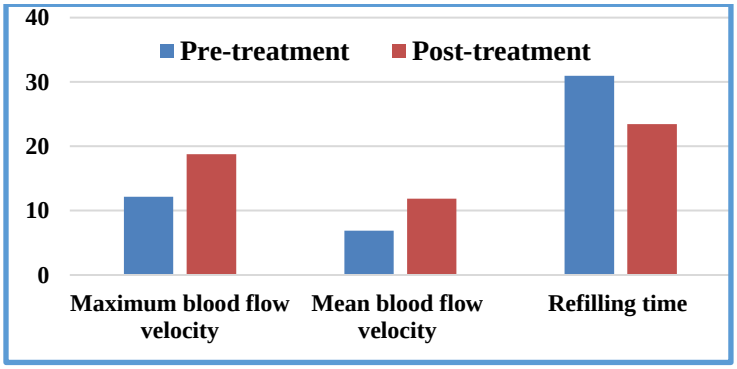

Figure (2): Mean values of pretreatment and post treatment data of left lower limb in intermittent pneumatic compression group

2. Exercise group: Right lower limb (Maximum blood flow velocity, mean blood flow velocity, and refilling time): Fig(3)

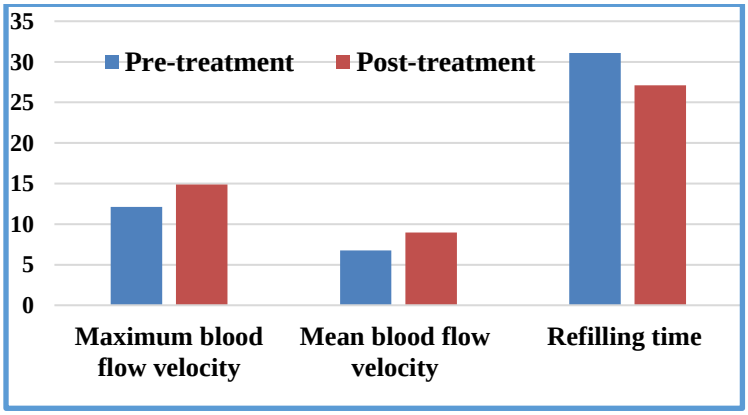

Figure (3): Mean values of pretreatment and post treatment data of right lower limb in Exercise group

3. Left lower limb (Maximum blood flow velocity, mean blood flow velocity, and refilling time): fig (4)

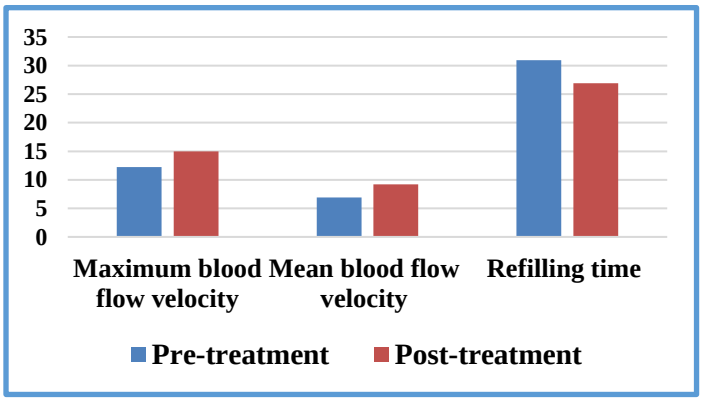

Figure (4): Mean values of pretreatment and post treatment data of left lower limb in exercise group.

3- Comparison of mean values of both groups pre-treatment and post-treatment:

4. **Unpaired t-test for post-treatment data of exercise and intermittent pneumatic compression groups: fig (5)**

Variable	Intermittent pneumatic compression Mean ± S.D	Exercise group Mean ± S.D	t value	P value	Significance
Maximum blood flow velocity	18.59±2.58	14.94±1.85	8.12	Less than 0.0001	Significant
Mean blood flow velocity	11.79±1.82	9.08±1.04	9.16	Less than 0.0001	Significant
Refilling time	23.77±2.42	27.02±1.67	7.82	Less than 0.0001	Significant

S.D: Standard deviation p: Probability value t: t test

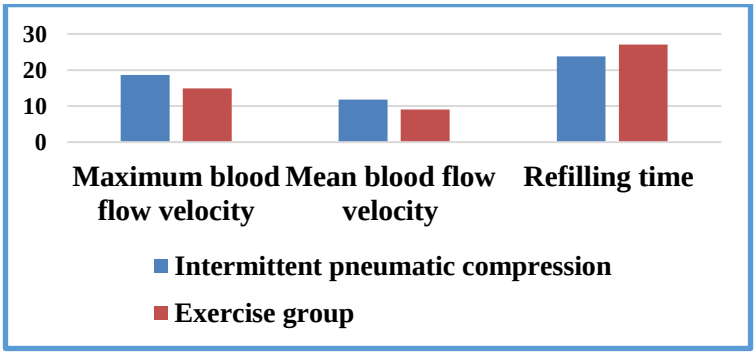

Figure (5): Mean values of post treatment data of both groups

DISCUSSION

Venous disease resulting from valve reflux appear to be the underlying pathophysiology for the formation of varicose veins rather than failure of blood flow from distal to proximal and/or from superficial to deep or incompetent valves in the

venous system to allow blood flow in the reverse direction (Bergen et., al 2006).

The gold standard for diagnosing varicose veins is ultrasound examination. It is ideal for optimal visualization of anatomy, hemodynamics, and the diameter of the veins, and reflux time which can be measured accurately (Partsch et al., 2007).

The purpose of this study was to determine the effect of strengthening exercise versus intermittent pneumatic compression to the calf muscle on the improvement of blood flow in patients with varicose veins and pain intensity.

Many variables were measured and discussed in an effort to explain the results of the current study. These variables were maximum and mean blood flow velocities measured in cm/ sec and refilling time measured in cm/sec and refilling time measured in second by using color duplex Doppler machine and pain intensity level by using visual analogue scale.

Result of group A were in accordance with some previous studies that recommended and supported like study which investigated that SPC therapy emerged as an effective treatment in the management of varicose veins, offering a clinically significant improvement in both venous blood flow and pain. These benefits were paralleled by significant improvements in pain intensity (Abeer et al., 2016).

IPC is generally a painless and non-invasive technique with proven efficacy as a valuable adjunct in the management of patients with venous, lymphatic, and arterial disease (Comerota et al., 2009).

The current study proved that IPC has significant effects on venous blood flow based on the following physiological effects. IPC increases the velocity of venous return and reduces the amount of blood inside the veins at any time through stimulation of endothelial cell production of nitric oxide and creates shear stress on the walls of blood vessels, which is the probable physiologic mechanism for enhanced nitric oxide production. Increased nitric oxide production inhibits platelet aggregation and neutrophil adherence, both of which play important roles in the creation of secondary hypoxic injury. Nitric oxide is also a neurotransmitter that can influence vascular tone, thereby increasing blood flow (Capps SG 2009).

These results are in agreement with the study of (Kakkos et al 2005) who revealed the hemodynamic superiority of sequential compression compared with other compression device (Griffin et al., 2007). (Figueiredo et al.2008). Found that use of IPC improves blood flow when applied in legs or thighs. Other studies have consistently concluded that all intermittent compression systems produce changes in femoral vein velocity. At pressures of around 40 mmHg, the typical maximum velocities achieved with calf and/or thigh compression would be 35–60 cm/sec with augmentations (maximum velocity during compression compared with maximum velocity at rest) of around 50–250%.

Result of group B were in accordance with some previous studies that recommended and supported the isotonic strength of calf muscle and the associated changes in great safeness veins as, (Clarke et al., 2006) their study aimed to explain the option of stimulation calf muscle contraction through externally applied neuromuscular electrical stimulation (NMES) and to measure venous blood flow response to this stimulation. They found a significant increase in venous velocities on voluntary contraction of the calf muscle. The study showed a positive homodynamic response to NMES.

Also the results of the current study were comparable with (Van Uden et al.2005) who pointed to the possible role for gait and strength training in the rehabilitation process of patients with severe chronic venous insufficiency. Improvement of gait parameters and increased calf muscle endurance were recorded after a selected program of gait training.

This study also agreed with (Pad berg et al., 2004) who postulated that the calf muscle pump function and the dynamic calf muscle strength were improved after a six months (three months of supervised therapy program designed to strengthen calf muscle and enhance joint mobility. They hypothesized that physical conditioning structured exercise to enhance calf muscle strength and ankle mobility would improve venous hemodynamic and improving calf muscle pump function. Furthermore, the results of this study agree with that recorded by (Zajkowski et al, 2002), who used four brands of knee-thigh compression stockings to study the mechanism of action of compression stocking and to compare different brands of stocking in their physiological action. They concluded that surgical support stocking seems to be more effective in controlling venous reflux than in improving calf muscle pump function.

The suggested explanation of how elastic compression stocking has failed to add further improvement to treatment variables in varicose veins condition when added to exercise training, could be attributed to inabilities of some patients to follow the instruction about the number of hours of wearing the stocking, however this was not supported by any previous documented studies. So

the explanation of this is unclear at this point and its mechanism needs further work.

On the other hand, the results of the present study were contradicted with some previous studies that used compression stockings alone without the use of an exercise program in patient with CVI. As (Angoules AG 2014), who assessed, based on patient self-evaluation, the effectiveness of the therapeutic graduated compression stocking in the treatment of chronic venous insufficiency. They stated that the graduated compression stockings are believed to have the most effective design in the treatment of CVI.

Also, our study did not agree with (Jan et al., 2009). They did find that when stocking were worn by the subjects during their work day, calf diameter, venous luminal diameter and numbers of perforators all tended to significantly decrease in comparison with finding when not wearing graded compression stocking.

The mechanism was generally attributed in those previous studies to that compression stocking proved to be in (1) Significantly reducing the symptoms of CVI over extended period of time (2) Treatment of CVI across the disease severity (3) Improving the quality of life of CVI patients (4) Preventing the progression of CVI into more sever states of manifestation (Angoules AG 2014).

In this study, all patients performed lower limb exercises; these exercises result in blood being pumped back to the heart from the thigh, calf muscles, and veins in the arch of the foot. A strong calf and thigh muscles promote healthy blood circulation and minimizes vein disease (Agu et al., 2004).

CONCLUSION

According to the obtained results of this study, it could be concluded that both intermittent pneumatic compression device and exercise were had a significant beneficial effects on the maximal blood flow velocity, mean blood flow velocity and refilling time in varicose veins patients but IPC had more effect than exercise and wearing Open-toe elastic compression stock. IPC therapy emerged as an effective treatment in the management of varicose veins, offering a clinically significant improvement in venous blood flow.

Conflict Of Interest

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

OSA designed and performed the experiment and also wrote the manuscript. NGE, AFR and MWE performed continuous guidance and suggestions during the performance of the experiment, data analysis and reviewed the manuscript. All authors read and approved the final version.

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