



## Effect of exercise versus intermittent pneumatic compression on pain and calf muscle circumference in patients with varicose veins

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**Background & purpose:** *Varicose veins* may cause complications that require time away from work, in addition to being cosmetic annoyances. Improvements in treatment have shortened recovery times and reduced complications. This study was carried out to compare the impact of strengthening exercise versus *intermittent pneumatic compression (IPC)* in pain levels as well as calf muscle circumference in patients suffering from *varicose veins*. **Methods:** A total of fifty patients—twenty three males and twenty-seven females—reported varicose vein symptoms. They were between 35 and 55 years old. Each group of patients was given an equivalent number of patients. There were 25 patients in Group (A) who treated using intermittent pneumatic compression equipment; 11 were male and 14 were female. Group (B) included 25 patients (12 males and 13 females) who, used elastic compression stockings and engaged in ergometer as well as tip-toe strengthening exercises, for twelve weeks. Prior to and following the treatment program, all patients in both groups had their pain severity recorded using a visual analog scale (VAS), and their calf muscle circumference was evaluated using a tape measure. **Results:** Based on the findings of this research, both groups experienced statistically significant reductions in pain intensity in favored IPC over exercise. Both groups showed no statistically significant changes in calf muscle circumference. **Conclusion** Although there was no statistically significant difference in calf muscle circumference between the two groups, the results showed that IPC was 9.32% more effective than exercise in lowering pain intensity.

**Keywords:** Varicose vein, intermittent pneumatic compression, exercise, open toe stock, blood flow, pain.

### INTRODUCTION

*Varicose veins* are a prevalent and progressive disorder, the prevalence of which is subject to significant variability and will progressively worsen (Abdullah et al. 2024). Venous twisting, bulging, as well as a superficial appearance on the legs are common symptoms of *varicose veins*. The prevalence of *varicose veins* is commonly estimated to be quite substantial, although it varies greatly. They affect between 10% to 20% of males and 25% to 33% of females (AAM et al. 2020).

Instead of the incompetent or insufficient valves in the venous system allowing blood flow in the opposite direction or disruption of blood flow from superficial to deep, venous disease caused by *valve reflux* is the that underlies pathophysiology for the development of

*varicose veins* (George et al. 2017).

IPC devices consist of air-filled sleeve- or boot-shaped chambers as well as electrical pumps having gauges that deliver intermittent compression to the lower limbs. Sequential pneumatic compression, or SPC, is the application of a compression force to the calf whether uniformly utilizing a single chamber device or sequentially from the ankle to the thigh via a sequence of chambers inflated (Al Daker et al. 2022).

Regeneration of fibrosis, enhancement of the efficacy of the muscular-articular pump, and improved tissue fluid penetration to the early lymph vessels are all outcomes of compression therapy (Meijer, et al.2016). The foot, calf, along with thigh is all parts of the lower limb that have pumps. The most significant of them is

the calf muscle pump due to its great efficiency, huge capacitance, and exceptional pressure generation (200 mm of mercury during muscular contraction). With a venous capacity of 100–150 cc and a calf volume of 1500–3000 cc, a typical limb can eject 40–60% of its venous volume with only one contraction (Padera and Uhl, 2015)

In this study, researchers aimed to compare the effects of strengthening exercises and IPC on the pain levels and circumference of the calf muscles of individuals with varicose veins. This study was carried-out from December 2023 to April 2024 at the Samalout Healthy Insurance Clinic, and Deraya University Center of Physical Therapy at Minya Governorate, Egypt.

## MATERIALS AND METHODS

This study included fifty men and women suffering from varicose veins of the lower limbs. They were randomly assigned to participate in this study and approved from Deraya University ethical committee (No P.T./REC/230001). Written consent was obtained.

All the patients had first-degree venous insufficiency based on the clinical, etiological, anatomical as well as pathophysiologic classification, with no signs or symptoms of venous flow obstruction and/or ulceration. Obesity and its associated health concerns can be estimated using the body mass index (BMI), which is a measurement of height and weight. A patient's BMI is calculated by dividing their weight in kilograms by the square of their height in meters (Nuttall, 2015).

### Inclusion criteria:

Patients with symptomatic varicose vein C2 (classified as a clinical severity class of the CEAP classification) the study included individuals who had experienced lower-limb pain, soreness, burning, discomfort, throbbing, heaviness in legs, muscle cramps or tiredness, or nocturnal cramps for a minimum of six months, Patients with bilateral varicose veins, they were aged from 35 to 55 years, BMI ranged from 30-34.9 kg/m<sup>2</sup>. (Class I, obese).

### Exclusion criteria:

Patients with any of the subsequent conditions were eliminated from the study: Patients who were medically unstable (those with uncontrolled diabetes, uncontrolled angina pectoris, or ischemic heart disease), Incompetent sapheno-femoral junction, Liver cirrhosis, Orthopedic problems or fractures of the lower limb, Cancer patients, and Pregnant women.

### Methods:

Fifty patients were homogenously assigned to two groups:

Group (A) included 25 patients who received an intermittent pneumatic compression device.

Group (B) included 25 patients who received tip-toe strengthening exercises and ergometer exercises using elastic compression stockings.

All the study parameters were detected and collected for each patient according to the evaluation sheet before and after twelve weeks of rehabilitation.

Lower-limb exercise was the primary form of exercise for all patients in both groups. It comprised isometric exercises of the quadriceps muscle and gluteus, as well as active flexion and extension of hip and knee, dorsiflexion, plantar flexion and straight leg rising.

### Evaluation procedure

The following parameters were studied: pain intensity measured by the VAS and calf muscle circumference measured with a centimeter tape for all participants in both groups at baseline and following 3 months of the treatment program.

#### Pain intensity level measurement:

The visual analogue scale was utilized for the purpose of measuring pain. The subjects were informed that the VAS was a 10-centimeter horizontal line with a zero-point scale for no pain and a ten-point scale for the worst pain they had ever experienced. To determine the severity of their pain, patients were requested to place a mark on a pain scale from zero to ten (Delgado et al. 2018)

#### Calf Muscle Circumference:

Calf muscle circumference was measured in centimeters at its maximum diameter while the patients were lying in a relaxed supine position. Measurements were taken from a fixed point of each patient's posterior knee crease using standard measuring tape (Delis et al. 2001).

#### Slandered Weight and Height Scale:

Each patient's height as well as weight was recorded. The formula for BMI is weight divided by the square of height (kg/m<sup>2</sup>).

### II. Treatment procedure:

Patients in both groups were instructed to start sessions with stretching of the calf muscle as they warmed up, and the same procedure was used at the end of the sessions as they cooled down. Both groups were instructed to perform the following exercise:

Patients had received isometric exercises of the quadriceps muscle and gluteus, as well as active flexion and extension of hip and knee, dorsiflexion, plantar flexion and straight leg raising <sup>(10)</sup> Patients had been wear open-toe elastic compression stockings throughout the day (Escamilla et al. 2024). (Care medical assistance. Healthy co. 34 – 46 mm hg.) Treatment for chronic venous insufficiency (CVI) patients mostly consists of leg compressions, with the idea being that gradient compression provides symptom relief and

better venous function. Even ancient Greeks and Romans utilized compression bandages to treat CVI (Bakar et al. 2016).

#### A- Exercise program for both groups.

##### 1- Gluteal isometric exercises (gluteal sets)

The buttocks were squeezed together. The mixture was held for five seconds and released, and this process was repeated 10 times.

##### 2- Isometric quadriceps exercises (quad sets)

With the leg straight, the muscles on top of the leg were tightened as much as possible and held. The knee became flat, and the knee cap moved slightly upward. The cells were incubated for five seconds, and this process was repeated 10 times.

##### 3- Knee flexion

Prone lie. The knee should be bent as far as possible. Then, the lower leg was relaxed, and the test was repeated 10 times.

##### 4- Knee extension

Sitting: straightened leg Hold for five seconds. The lower leg was relaxed, and the test was repeated 10 times.

##### 5- Ankle dorsiflexion/planter flexion (ANKLE PUMP)

Move the foot up and down as if pushing or letting up on a gas pedal in a car.

While lying on the back, the quad set (above) is used to lift the right leg straight up slowly to approximately 45. The tension was increased, the lower leg was slowly relaxed, and the test was repeated 10 times.

Patients in group (A) were instructed to perform IPC for 30 minutes three times a week for three months.

The patient was asked to maintain a comfortable position (half lying). Patients were treated with an intermittent pneumatic compression device (consisting of four overlapping chambers). The compression sleeve was fitted to the patient's extremity. The compression device is linked to the deflated sleeve using a rubber hose as well as a connecting valve. Two parameters had been modified after the machine had been switched on: total treatment time in addition to inflation pressure (time of deflation and inflation). The treatment session lasted thirty minutes, three sessions per week for 12 weeks. The device inflation time was 15 seconds, and relaxation was 2.4 seconds to allow venous refilling (Babber et al. 2021)

Patients in group (B), the exercise group, were instructed to perform the following:

##### Tip-toe strengthening exercise:

The exercise program for the patients involved them standing erect on a 5-centimeter-high step, with their balls of the feet touching the edge. After being told to

slowly bring their heels down to the floor, the patients were told to slowly bring them up as high as they could go. Everyone was instructed to touch a side rail so they wouldn't lose their balance while exercising (Ashraf et al. 2013).

Each patient was evaluated before the exercise program began to establish the maximum number of tip-toe exercises which could be completed in the given six minutes.

In the first part of the program, patients were instructed to conduct three sets of twenty-five repetitions of tip-toe exercises at 50% their maximum capacity, with a five-minute break between each set.

Patients were instructed to execute three sets of tip-toe exercises three times weekly for six weeks throughout the second half of the program, building up to the maximum number of repetitions they could do on the first pre-training test (Vratna et al. 2022).

##### Foot ergometer exercise:

Patients underwent isotonic training of the calf muscle for twelve weeks (Bergenthal et al. 2019).

A standardized 6.5 kg resisted pedal ergometer was used to have the patients engage in active plantar flexion for duration of six minutes. While on the examination couch, patients were instructed to position their heels firmly on the seat back of the ergometer pedal and knees slightly bent over a pillow.

Each patient was evaluated before the exercise program began to establish the maximum number of flexion's that could be achieved in 6 minutes at a rate of one flexion per second.

Every training session was started with half of the maximum flexion that could be achieved at baseline, and then gradually raised to 360 flexion over the course of the following six weeks (Ashraf et al. 2013).

Patients engaged in 3 sets of six-minute flexion exercises for both feet during each session. Each set was performed at a rate of one flexion each second, followed by a five-minute interval between consecutive sets for recovery<sup>(14)</sup>. The exercise was conducted three times per week for twelve weeks. Patients were instructed to perform ergometer exercise for six minutes with a five-minute rest period (Knips et al. 2019).

##### Data analysis:

To test the study hypothesis, the following statistical methods were used:

Descriptive statistics for all measured parameters are represented as the mean  $\pm$  standard deviation (SD).

Inferential statistics in the form of Paired t tests were utilized to compare the results of the same group for both legs and to compare the differences between the two legs.

Independent t tests were utilized to determine differences between two groups.

**Statistical analysis:**

The findings are represented as the mean ± standard deviation (SD). A dependent Student's t test was used to compare the mean VAS scores prior to and following treatment within the same group, and an independent Student's t test was used to compare the mean values of different parameters among the two groups. For this data, we utilized the statistical package SPSS (Windows, version 12). It was regarded as significant if the P value was below or equivalent to 0.05.

**RESULTS**

This study aimed to compare the effectiveness of strengthening training with IPC in reducing calf muscle pain and measuring calf muscle circumference in individuals with varicose veins. Measurements were taken both prior to and after 12 weeks of treatment.

The independent variable of the study was intermittent pneumatic compression. Two groups were studied: the intermittent pneumatic compression group (A) and the exercise group (B). The results of the study are as follows:

**Patient characteristics**

Fifty participants of both genders participated in the study. The patients were diagnosed with varicose veins. Ages varied from 35 to 55. There were two equivalent groups to which individuals were assigned at random. In terms of age, weight, height, as well as BMI, no statistically significant differences were found between the groups (Tables 1 and 2). Furthermore, when comparing the percentages of males and females within groups, no significant differences were found.

. Table (1): characteristics of both groups.

Variables	Intermittent pneumatic compression group	Exercise group	Comparison		Significance
	Mean $\bar{X} \pm S.D$	Mean $\bar{X} \pm S.D$	t value	p value	
Age(Years)	43.88 ±6.73	44.52 ±6.23	0.35	0.73	N.S
Weight	84.95 ±8.77	83.22±8.28	0.72	0.48	N.S
Height	1.61±0.07	1.59±0.06	1.32	0.19	N.S
BMI	32.59±1.35	32.93±1.004	1.009	0.32	N.S

$\bar{X}$  : Mean  
 SD: Standard Deviation MD: Mean difference  
 T value: Unpaired t value p value: Probability value NS: Non significant

**Table (2): Distribution of males and females in both groups**

	MALE	FEMALE	TOTAL
Intermittent pneumatic compression group	11	14	25
Exercise group	12	13	25
Total	23	27	50

The chi-square is 0.08, while the p value is 0.78. This result is not significant at p < .05.

II. Comparison of the mean values of each group pretreatment and post treatment.

1- Group (A) Intermittent pneumatic compression group:

**Right lower extremity:**

Results from paired t-tests comparing pain and calf muscle circumference before and after treatment (p <

**0.0001) are presented in Table (3)**

**Left lower limb:**

As shown in Table (4), paired t tests revealed significant differences in pain and calf muscle circumference between pretreatment and post treatment data, with p values less than 0.0001.

**Group (B) Exercise group:**

**Right lower limb:**

Results from paired t tests showing a statistically significant difference (p < 0.0001) among before and after treatment data on pain and calf muscle circumference are presented in Table (5).

**Table (3): Paired t test for the intermittent pneumatic compression group (right lower limb):**

Variable	Pretreatment Mean $\bar{X} \pm S.D$	Post treatment Mean $\bar{X} \pm S.D$	MD	percentage	t value	P value	significance
Visual analog scale	7.46±0.99	3.62±0.53	-3.84	51.47%	34.67	Less than 0.0001	Significant
Calf muscle circumferences	39.58±2.39	39.33±2.4	0.25-	0.63%	105.7	Less than 0.0001	Significant

: Mean SD: Standard Deviation MD: Mean difference  
T value: Unpaired t value p value: Probability value S: significant

**Left lower limb:**

As shown in Table 6, paired t tests showed that there was a significant difference in pain and calf muscle circumference among the pretreatment and post-treatment data, with p values less than 0.0001.

**Comparison of the mean values of both pretreatment and post treatment groups:**

**A- For the pretreatment data:**

Table (7) shows the results of an independent t test

**Table (4): Paired t test for the intermittent pneumatic compression group (left lower limb):**

Variable	Pretreatment Mean $\bar{X} \pm S.D$	Post treatment Mean $\bar{X} \pm S.D$	MD	Percentage	t value	P value	significance
Visual analog scale	7.4±1.1	3.5±0.52	-3.9	52.70%	28.8	Less than 0.0001	Significant
Calf muscle circumferences	39.58±2.39	39.31±2.4	-0.27	0.68%	81.38	Less than 0.0001	Significant

: Mean SD: Standard Deviation MD: Mean difference  
T value: Paired t value p value: Probability value S: Significant

which showed that neither the pain nor the circumference of the calf muscles were significantly different between the groups.

**B- For the post treatment data:**

The results of an independent t test showing a significant difference among the groups with respect to pain (p < 0.0001) are presented in table (8). With a t-value of 0.25 and a probability value of 0.799, no statistically significant difference was found between the groups when it came to calf muscle circumference.

**Table (5): Paired t test for the exercise group (right lower limb):**

Variable	Pretreatment Mean $\bar{X} \pm S.D$	Post treatment Mean $\bar{X} \pm S.D$	MD	Percentage	t value	P value	Significance
Visual analog scale	8.12±0.803	4.68±0.64	-3.44	42.36%	34.67	Less than 0.0001	Significant
Calf muscle circumferences	39.78±2.57	39.46±2.55	-0.32	0.80%	18.76	Less than 0.0001	Significant

: Mean SD: Standard deviation MD: Mean difference  
T value: Paired t value p value: Probability value S: Significant

**Table (6): Paired t test for the exercise group (left lower limb):**

Variable	Pretreatment Mean $\bar{X} \pm S.D$	Post treatment Mean $\bar{X} \pm S.D$	MD	Percentage	t value	P value	significance
Visual analog scale	7.9±0.64	4.54±0.52	-3.36	42.53%	35.89	Less than 0.0001	Significant
Calf muscle circumferences	39.77±2.57	39.46±2.55	-0.31	0.77%	19.33	Less than 0.0001	Significant

$\bar{X}$  : Mean SD: Standard Deviation MD: Mean difference  
t value: Paired t value p value: Probability value S: Significant

**Table (7): Unpaired t test for pretreatment data of the exercise and intermittent pneumatic compression groups:**

Variable	Intermittent pneumatic compression	Exercise group Mean $\bar{X} \pm S.D$	t value	P value	Significance
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	Mean $\bar{X} \pm S.D$				
Visual analog scale	7.66±1.13	8±0.73	1.79	0.077	Not significant
Calf muscle circumferences	39.58±2.37	39.78±2.55	0.404	0.69	Not significant

: Mean SD: Standard Deviation MD: Mean difference  
 T value: Paired t value p value: Probability value NS: Not Significant

**Table (8): independent t-test for post treatment data of the exercise and intermittent pneumatic compression groups:**

Variable	Intermittent pneumatic compression Mean $\bar{X} \pm S.D$	Ex. group Mean $\bar{X} \pm S.D$	MD IPC	% IPC	MD Ex.	%Ex.	t value	P value	S.
Visual analog scale	3.7±0.63	4.61±0.58	-3.96	51.69%	-3.39	42.37%	7.49	Less than 0.0001	S.
Calf muscle circumferences	39.33±2.37	39.46±2.52	-0.25	0.63%	-0.32	0.80%	0.25	0.799	Not S.

: Mean SD: Standard Deviation MD: Mean difference NS: Not significant  
 T value: Paired t value p value: Probability value S.: significant Ex.: Exercises. S: Significant

## DISCUSSION

This study was carried out to compare the impacts of strengthening exercises versus in terms of pain intensity as well as calf muscle circumference. Both the pain level and the circumference of the calf muscles have been measured utilizing and tape measures, respectively.

The participants in this trial all engaged in lower limb activities, which activated the veins in the arch of the foot, the muscles within the thigh as well as calf muscles, and then pumped blood back to the heart. Leg and calf muscles that are strong reduce the risk of vein disease and improve blood circulation. Group A's findings confirmed those of other research that had previously suggested and supported IPC therapy as a viable option for varicose vein care since it significantly reduced pain and improved venous blood flow. Significant reductions in pain intensity occurred simultaneously with these advantages (Morris and Woodcock, 2010).

Furthermore, the group (A)'s findings were in line with those of Mandini, et al.2022, which suggested that gait and strength training could play a part in the rehabilitation of individuals suffering from severe chronic venous insufficiency. Results showed that after completing a specific gait training program, participants' gait characteristics improved and their calf muscle endurance rose.

According to the following physiological consequences, the present investigation established that IPC significantly affects venous blood flow. As a result of increasing shear stress on the walls of blood vessels and stimulating endothelial cells to produce of nitric oxide, IPC enhances the velocity of venous returns and decreases the amount of blood within the veins at any given time. This is likely to be the physiological

mechanism for improved nitric oxide the production process. Platelet aggregation as well as neutrophil adherence is critical steps in the progression of secondary hypoxia damage; however, increased nitric oxide generation slows both processes. Another neurotransmitter that has the ability to increase blood flow is nitric oxide (Capps, 2009). When used as an auxiliary tool in the treatment of venous, lymphatic, as well as arterial disease, IPC is typically a painless and noninvasive procedure that has demonstrated effectiveness (Aziz and Comerota, 2009).Swelling causes greater tissue tension, which in turn causes pain in varicose vein patients. Accordingly, relief of pain is possible by reduction of edema. By enhancing venous pump function as well as lymphatic drainage, as well as by promoting venous return towards the heart, compression therapy opposes venous hypertension. By raising the local hydrostatic pressure and reducing the superficial venous pressure, it decreases edema, which in turn improves cutaneous blood flow, lowers pain, and stops the leaking of fluids and macromolecules (Singh and Zahra, 2024). Yamany and Hamdy, 2016 found that successive pneumatic compression therapy according to the applied parameters increased venous blood flow, decreased pain, and improved quality of life for women suffering from varicose veins. This study's results are consistent with those findings. Alpagut et al. 2021 also found similar results, suggesting that gait and strength training may play a part in the rehabilitation of patients suffering from severe chronic venous insufficiency. After completing a chosen gait training program, participants showed improvements in gait outcomes measurements and enhanced calf muscle endurance. Consistent with Silva et al. 2021 this investigation found that following six months (3 months of a supervised treatment program to strengthen calf muscles along with improving joint mobility), both dynamic calf strength as well as calf

muscle pump function improved. The researchers proposed that by strengthening the calf and mobilizing the ankles more effectively, an individual's venous hemodynamics could be improved (CP, et al. 2021). Moreover, this study's findings are in agreement with those of Flavell, et al. 2016 who compared the physiological effects of four distinct types of knee-thigh compression stockings and studied the mechanism underlying the action of compression stockings. Rather than enhancing calf muscle pump performance, surgical support stocking appears to be more beneficial in reducing venous reflux, according to their findings.

Furthermore, Jeanneret et al. 2014 disagreed with our study. Results showed that compared to when people weren't wearing graded compression stockings, calf muscle diameter, venous lumen diameter, and the total number of perforators all decreased significantly when individuals wore the stockings throughout the work day.

The mechanism was generally thought to be due to the following: (1) compression stockings considerably reduce CVI symptoms across time; (2) they treat CVI regardless of disease severity; and (3) they enhance the quality of life among CVI patients, and (4) prevent the progression of CVI to more severe manifestations (AG, 2014).

## CONCLUSIONS

According to the results of this study, IPC had a greater beneficial effect than exercise on reducing pain intensity by 9.32%, while it had no significant effect on calf muscle circumference. *Varicose veins* can now be effectively treated with IPC therapy, which improves venous blood flow by a significant clinical margin. There is a marked decrease in the severity of pain associated with these advantages.

## Supplementary materials

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## Author contributions

All authors have read and agreed to the published version of the manuscript.

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## Data Availability Statement

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## Conflict of interest

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

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## REFERENCES

- AAM, Abou-EIWafa, El-Gilany, El-Metwaly, 2020: Lower Limb Varicose Veins among Nurses: A Single Center Cross-Sectional Study in Mansoura, Egypt. *Indian J Occup Environ Med.* 2020 Sep-Dec; 24(3):172-177. Doi: 10.4103/ijoem.IJOEM\_264\_19. Epub 2020 Dec 14. PMID: 33746431; PMCID: PMC7962502.
- Abdullah, Alsubari, Ekhaton, F., Fayyaz, Vaghani, V., C., M., R. A., Daher, O. A., Bakht, D., Batat, H., Arif, H., Bellegarde, S. B., Bisharat, P., & Faizullah, M, 2024: Advancements in Varicose Vein Treatment: Anatomy, Pathophysiology, Minimally Invasive Techniques, Sclerotherapy, Patient Satisfaction, and Future Directions. *Cureus*, 16(1), e51990. <https://doi.org/10.7759/cureus.51990>
- AG., 2014: Conservative treatment of chronic venous insufficiency. *Journal of Novel Physiotherapies*; 5(1):1-2.
- Al Daker, Alhamadh, Alqirnas , Khan., 2022: The association of timing of pharmacological prophylaxis and venous thromboembolism in patients with moderate to severe traumatic brain

- injury: A retrospective cohort study. *Ann Thorac Med* 2022; 17:102-9.
- Alpagut, Gürdal, Ipek, Tulin, 2021: The efficiency of exercise training in patients with venous insufficiency: A double blinded, randomized controlled trial. *Phlebology.*; 36(6):440-449. Doi: 10.1177/0268355520985759
- Ashraf, Abdelaal, Omar Helal and Alayat, 2013: Change in the great saphenous vein diameter in response to contrast baths and exercise: a randomized clinical trial. *Journal of American science*, 9(3):476-483.
- Aziz and Comerota, 2009: The case for intermittent pneumatic compression. *Clinical review. J Lymphoedema*, 4: 57–64.
- Babber , Babber ,Ravikumar , Lane , Onida , x . 2021:A randomized controlled trial of neuromuscular stimulation in nonoperative venous disease improves clinical and symptomatic status. *Phlebology.* May; 36(4):290-302. Doi: 10.1177/0268355520968640. Epub 2020 Nov 11. PMID: 33176593; PMCID: PMC8044600.
- Bakar Duygu ,Özdemir , Sevim , Tuğral , . 2016: The effects of short-term use of compression stockings on health related quality of life in patients with chronic venous insufficiency. *J Phys Ther Sci.* 2016 Jul;28(7):1988-92. Doi: 10.1589/jpts.28.1988. Epub 2016 Jul 29. PMID: 27512248; PMCID: PMC4968490.
- Bergenthal, Elter, Knips, Monsef, Skoetz Streckmann, , 2019: Aerobic physical exercise for adult patients with hematological malignancies. *Cochrane Database Syst Rev.* 2019 Jan 31; 1(1):CD009075.
- Capps, (2009): Cryotherapy and intermittent pneumatic compression for soft tissue trauma. *Athl Ther Today*, 14: 2–4.
- CP, EAB, KLS, et al., 2021 The impact of exercise training on calf pump function, muscle strength, ankle range of motion, and health-related quality of life in patients with chronic venous insufficiency at different stages of severity: a systematic review. *J Vasc Bras.* 2021; 20:e20200125.
- Delgado, Lambert, Boutris, McCulloch, Robbins, Moreno, and Harris, 2018. Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *J Am Acad Orthop Surg Glob Res Rev.* 2018 Mar 23; 2(3):e088. Doi: 10.5435/JAAOSGlobal-D-17-00088. PMID: 30211382; PMCID: PMC6132313.
- Delis, Kan, Man Konstantinos, and Yuk: 2001: Hemodynamic Effects of Supervised Calf Muscle Exercise in Patients with Venous Leg Ulceration. (2001) *Archives of surgery* (Chicago, Ill.: 1960). 136. 1364-9. 10.1001/archsurg.136.12.1364. Doi: 10.1002/14651858.CD009075.pub3. PMID: 30702150; PMCID: PMC6354325.
- Escamilla, R.F.; Thompson, I.S.; Carinci, J.; MacLean, D.; MacLean, L.; Aguinaldo and A.L. 2024: Effects of Ankle Position While Performing One- and Two-Leg Floor Bridging Exercises on Core and Lower Extremity Muscle Recruitment. *Bioengineering* 2024, 11, 356. <https://doi.org/10.3390/bioengineering11040356>.
- Flavell, Fox, Millner, Paton, Rice, Stansby, Wade, and Woolacott. (2016): Thigh length versus knee length antiembolism stockings for the prevention of deep vein thrombosis in postoperative surgical patients; a systematic review and network meta-analysis. *BMJ Open.* Feb 16; 6(2):e009456. Doi: 10.1136/bmjopen-2015-009456. PMID: 26883236; PMCID: PMC4762135.
- George, B., Santler, and T. 2017: Chronic venous insufficiency – a review of pathophysiology, diagnosis, and treatment. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft*, 15: 538-556.
- Jeanneret C, Karatolios K, von Planta I, 2014: Impact of compression stockings on calf-vein diameters and on quality of life parameters in subjects with painful legs. *Vasa.* 2014;43(4):268-277. doi:10.1024/0301-1526/a000362
- Mandini, Mandini, Mazzoni,Fabbri, Fogli , Menegatti, Pagani, Zerbini, Piva, Raisi, , et al.,2022: The Effect of Active Stretch Training in Patients with Chronic Venous Insufficiency Monitored by Raster-Stereography. *Sensors.*22(21):8509. <https://doi.org/10.3390/s22218509>.
- Meijer, Munn and Padera., 2016: The Lymphatic System in Disease Processes and Cancer Progression. *Annul Rev Biomed Eng.* 2016 Jul 11; 18:125-58. Doi: 10.1146/annurev-bioeng-112315-031200. Epub 2016 Feb 5. PMID: 26863922; PMCID: PMC4946986.
- Morris,and Woodcock, 2010: Intermittent pneumatic compression or graduated compression stockings for deep vein thrombosis prophylaxis? A systematic review of direct clinical comparisons. *Ann Surg*, , 251: 393–396.
- Nuttall, 2015: Body Mass Index: Obesity, BMI, and Health: A Critical Review. *Nutr Today.* 2015 May; 50(3):117-128. Doi: 10.1097/NT.0000000000000092. Epub 2015 Apr 7. PMID: 27340299; PMCID: PMC4890841.
- Padera , and Uhl.,2015: Anatomy of the veno-muscular pumps of the lower limb. *Phlebology.* 2015 Apr; 30(3):180-93. Doi: 10.1177/0268355513517686. Epub 2014 Jan 10. PMID: 24415543.
- Singh and Zahra.,2024: Chronic Venous Insufficiency. [Updated 2023 Apr 27]. In: *StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK587341/*.
- Vrátná, Et al., Husáková,Jarošíková, R., Dubský, M., Wosková, V., Bém, R., Jirkovská, A., Králová, K.,



Pyšková, B., Lánská, V., & Fejfarová, V., 2022 : Effects of a 12-Week Interventional Exercise Programmed on Muscle Strength, Mobility and Fitness in Patients With Diabetic Foot in Remission: Results From BIONEDIAN Randomized Controlled Trial. *Frontiers in endocrinology*, 13, 869128. <https://doi.org/10.3389/fendo.2022.869128>.

Yamany and Hamdy., 2016: Effect of sequential pneumatic compression therapy on venous blood velocity, refilling time, pain and quality of life in women with varicose veins: a randomized control study. *J Phys Ther Sci*. Jul; 28(7):1981-7. Doi: 10.1589/jpts.28.1981. Epub 2016 Jul 29. PMID: 27512247; PMCID: PMC4968489.