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Effects of intermittent pneumatic compression on pain in women with lipedema

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Abstract

Background: Lipedema is a chronic pain disorder characterized by disproportionate adipose tissue accumulation and pain of the affected extremities. While medical compression therapy is recommended for pain reduction, evidence regarding the additional benefit of intermittent pneumatic compression (IPC) remains limited. The aim of this study was to evaluate the effect of IPC on pain in patients with lipedema already receiving compression therapy.

Methods: Retrospective investigator-initiated analysis of 100 consecutive questionnaires from women with physician-diagnosed lipedema that underwent a home-based IPC trial provided by a medical device company. Pain intensity was recorded on a 0–10 numerical rating scale (NRS) before initiation of IPC and after 10–14 days of treatment. Information on (obsolete) lipedema stage, body characteristics, compression therapy and manual lymphatic drainage (MLD) was collected. Changes in pain scores were analysed.

Results: 90 patients already receiving manual lymphatic drainage and compression garments were evaluated. Mean/median age of the participants was 48.8/48 years (SD 13.8). Mean/median body mass index was 32.1/31.2 kg/m^2 (SD 6.7). 5 patients were classified as lipedema stage I, 58 stage II, 24 stage III. Prior to IPC, the mean/median pain score was 6.5/6.0 (SD 1.56), decreasing to 3.8/4 (SD 1.55) after treatment. The mean/median reduction in pain was 2.7/3.0 points ($p < 0.001$). No patient reported worsening of pain. The (obsolete) lipedema stages did not influence pain scores or pain reduction.

Conclusion: In this cohort of patients with lipedema already receiving compression therapy and MLD the short-term intermittent pneumatic compression (IPC) use was associated with a significant reduction in self-reported pain. The observed effect was independent of (obsolete) lipedema stage. In addition to pain relief, many patients reported improvements in mobility and tissue quality. Prospective controlled studies are warranted to further evaluate the role of IPC in the management of lipedema.

Keywords

compression, intermittent pneumatic compression, lipedema, patient reported outcomes

Introduction

Lipedema is a painful disorder. Affected women exhibit a disproportionate distribution of adipose tissue between the abdomen and the extremities, similar to lipohypertrophy, but with the key difference that the adipose tissue is painful. Despite its misleading name, fluid accumulation does not play a role in lipedema. There is increasing evidence of endothelial cell migration, inflammation, increased collagen formation,[1] and endothelial cell-derived signals that promote adipocyte growth and proliferation.[2,3] These findings indicate alterations in the composition and microenvironment of adipose tissue in lipedema, which may contribute to the associated pain. In phlebology, the role of inflammatory markers in varicose veins is well established, as are the effects of compression on structural changes in the venous wall and on the concentration of inflammatory markers within the vein wall.[4–8]

Compression stockings reduce pain in patients with lipedema, at least according to our daily clinical experience. Although the available evidence is not yet robust, it is sufficient for the current German guideline on lipedema to recommend medical compression therapy for pain reduction. However, no large prospective studies have yet compared compression hosiery with no compression in the treatment of

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lipedema.[9] Evidence concerning intermittent pneumatic compression (IPC) in lipedema is similarly scarce; the few available studies have involved only small patient groups or assessed the effects of a single treatment session.[9,10]

From a pragmatic perspective, the question therefore remains as to the extent to which medical compression hosiery and intermittent pneumatic compression (IPC) reduce pain in patients with lipedema. In clinical practice, affected women repeatedly report that they perceive IPC in addition to daily compression hosiery as effective and pain-relieving, even though all of these patients are already using compression stockings providing an ankle pressure of 22–28 mmHg.

The author therefore intended to conduct a study to assess the effectiveness of IPC in reducing pain in patients with lipedema who were already receiving the classical compression therapy. In Germany, IPC devices are only reimbursed in case of lipedema, if the patient has not enough pain relieve with compression garments alone or in addition with MLD. The author approached Bösl, which acted as a partial sponsor of the study. Following discussions with the manufacturer, it was decided that, as a first step, the existing data sheets of 100 patients with a diagnosis of lipedema and currently in treatment with compression garments, who had received an IPC device during the preceding 3 months would be evaluated.

The aim of this analysis was to determine whether, and to what extent, IPC could further reduce pain in patients who were already being treated with compression hosiery.

Methods

This investigator-initiated analysis evaluated existing data sheets provided by Bösl to assess the additional effect of IPC on pain in patients with lipedema of the lower extremities who were undergoing regular treatment with compression hosiery.

A total of 100 consecutive questionnaires completed during the first quarter of 2026 were evaluated. The questionnaires were obtained from patients with a diagnosis of lipedema who had been provided with an IPC device as an adjunct to compression hosiery therapy.

Bösl supplies IPC devices to patients through medical device consultants for a trial period required by many health insurance providers. During this period, it is assessed whether the device is tolerated, whether the patients are able to operate it independently, and what effects the treatment has. For this purpose, patients are asked to complete a standardized questionnaire.

The medical device consultant provides each patient with in-person instructions on the handling and operation of the IPC control unit and treatment garments, including the application pressure and treatment duration. Because tolerance of compression pressure varies considerably among patients with lipedema, according to guidelines[9] the treatment is initiated at a low application pressure during the instruction session—30 mmHg for lipedema of the lower extremities—and gradually increased to a pressure level perceived by the patient as comfortable and well tolerated. It is therefore important that patients are able to adjust the desired treatment pressure independently on the IPC control unit.

During the trial period, daily IPC treatment for at least 30 minutes is recommended. Longer treatment sessions may be performed depending on the patient's available time. They may choose whether to undergo treatment with or without their existing compression hosiery. The medical device consultant also documents the patient's other treatments, including manual lymphatic drainage (MLD) and compression therapy, as well as relevant patient characteristics.

Patients complete a standardized pain questionnaire on days 1, 4, 8, and 10, in each case before starting the IPC treatment session. The questionnaire includes a numeric

Table 1. Verbal description of pain intensity and NRS.

NRS score	Pain intensity	Description
0	Pain-free	I have no pain.
1	Minimal	I am barely aware of any pain.
2	Mild	I feel the pain only when I focus on it.
3	Uncomfortable	The pain is bothersome, but I can usually ignore it.
4	Moderate	I feel the pain constantly, but I can perform most activities.
5	Disruptive	I think about my pain almost all the time. I can no longer perform some daily activities.
6	Exhausting	I am constantly thinking about my pain and have to give up many activities because of it.
7	Unmanageable	I am in constant pain and can hardly do anything.
8	Intense	My pain is so severe that I can hardly think about anything else. Speaking and listening are difficult.
9	Very severe	My pain is so severe that I find it difficult to speak or move.
10	Incapacitating	I am confined to bed and can no longer move. Someone must take me to the emergency department immediately so that I can receive medical care.

rating scale (NRS) from 0 to 10. To assist them in rating pain intensity, they are provided with visual and written information: A visual analogue scale (VAS) from 0 to 10, coloured in green at 0-2, yellow in 3-5 and changing from light orange to dark red from 6-10. Besides, in the same colours, short and long descriptions of the pain stages are added (see Table 1). Besides, they receive the following instruction: "Pinch your skin first at a pain-free site and then at a painful site. This procedure will make it easier for you to assess your pain level."

The questionnaire also encourages patients to enter their own comments. The following instruction is provided: "If you observe any additional positive effects, please record them here (e.g., improved mobility, changes in tissue firmness, weight reduction, or skin changes)."

For the present analysis, a company-generated spreadsheet containing the transcribed results of 100 consecutive questionnaires was used. The dataset was provided to the author in fully anonymized form. The Ethics Committee of the Lower Saxony Medical Association was consulted and raised no objections to the analysis.

The following parameters were evaluated:

General characteristics:
- o year of birth, height, weight
- o lipedema stage as documented on the prescription according to the previous diagnostic classification system, which is currently still required for ICD coding and prescribing purposes.
- o Only women diagnosed with lipedema were included.

IPC treatment:
- o pain intensity on a visual analogue scale ranging from 0 to 10 before and at the end of the treatment period, corresponding to the assessments on days 1 and 10.

Previous and ongoing lipedema treatments:
- o duration of treatment with medical compression stockings in years;
- o type of compression garment (flat-knit or circular-knit); compression class; garment length (knee-high, thigh-high, or waist-high)
- o where applicable, duration of treatment with manual lymphatic drainage (MLD) in years, treatment frequency per week, and session duration.

Statistical analyses were performed using jamovi, version 2.6.45.0. The collected data were initially analysed descriptively. For continuous variables, the mean, standard deviation (SD), median, minimum, and maximum are reported. Categorical variables are presented as absolute and relative frequencies. Missing values were not imputed. All analyses were conducted using the available data for each analysis (available-case analysis). A paired-samples t-test was used to assess the change in pain intensity between the measurements obtained before and after the intervention. Because of unequal group sizes and heterogeneity of variances, a one-way Welch analysis of variance was performed to assess potential differences in pain intensity and pain reduction across lipedema stages. A Welch analysis of variance was also used to determine whether pain reduction differed according to the duration of the trial period (10 vs. 14 days). For all statistical tests, the significance level was set at $\alpha = 0.05$. All tests were two-sided.

Results

Only those patients receiving both treatmens (compression and MLD) were included in the evaluation.

The anonymized data sheets of 100 patients diagnosed with lipedema were analysed. 98 of the patients wore compression regularly, 95 received manual lymphatic drainage (MLD). To evaluate a homogenic group, only 92 patients receiving both – compression garments and MLD, were evaluated. 2 of them did not report pain scales, resulting in a final number of evaluated persons of 90.

The mean age was 48.8 years (median 48 years, SD 13.8; range 18–78 years). Height data were available for 87 patients. Mean height was 165 cm (median 164 cm; SD 6.33; range 150–182 cm). Mean body weight was 87.8 kg (median 89.0 kg; SD 19.6; range 51–155 kg). The mean body mass index (BMI) was 32.1 kg/m^2 median 31.2 kg/m^2; (SD 6.72; range 19.4–51.2 kg/m^2). Because height data

Table 2. General statistics of the evaluated group.

	Age	Height (cm)	Weight (kg)	BMI (kg/m^2)
N	90	87	90	87
Missing	0	3	0	3
Mean	48.8	165	87.8	32.1
Median	48.0	164	89.0	31.2
Standard deviation	13.8	6.33	19.6	6.72
Minimum	18	150	51	19.4
Maximum	78	182	155	51.2

Table 3. Previous treatment options: Compression, duration in years, compression class based on RAL and manual lymphatic drainage (MLD) therapy in years, frequency per week and duration of the sessions in minutes.

	Compression (years)	Compression class[a]	MLD (years)	Frequency per week	Duration in minutes
N (answers)	90	85	90	87	87
Missing	0	5	0	3	3
Mean	6.12	2.05	5.23	1.44	51.8
Median	4.00	2	4.00	1	45
Standard deviation	6.24	0.305	6.10	0.623	8.56
Minimum	0	1	1	0	30
Maximum	36	3	46	3	60

[a]RAL classification of compression class with indication of compression at the ankle: CCL I light compression: 18–21 mmHg; CCL II moderate compression: 23–32 mmHg; CCL III: strong compression; 34–46 mmHg.

were available for only 87 patients, BMI could likewise be calculated for only 87 patients (see Table 2).

Although the staging system for lipedema is no longer considered current according to the guideline, disease stage was recorded. 5 patients were classified as lipedema in the obsolete stage I (5,6%), 58 in obsolete stage II (64,4%), 24 in obsolete stage III (26,7%) (3 missing Stage).

Regarding previous compression hosery treatment the median treatment duration of 4 years. Compression class II was used most frequently. Of these patients, four used circular-knit garments and 84 used flat-knit garments. Various flat-knitted compression garment combinations were used, including knee-long stockings combined with cycling shorts or leggings, thigh-long stockings combined with Bermuda shorts, and panty garments. With the exception of two cases, treatment always consisted of a combination of two garments extending to the waist or panties.

The mean duration in years of MLD among the evaluated 90 patients was 5.23, the mean treatment frequency was 1.4 sessions per week. The mean duration of each treatment session was 51.8 minutes with a median if 45 minutes, ranging from 30–60 minutes) (see Table 3).

The mean pain score before treatment was 6.53, with a median of 60. After treatment, the mean pain score was 3.83, with a median of 4 (see Table 4).

No patient experienced an increase in pain. The change in pain intensity, reported as difference in Table 4, had a median from 3 points in NRS and ranged from 0 to eight points. Two patients experienced no change in pain intensity: one had a pain score of 3 and the other a pain score of 6. The reduction in pain intensity was statistically significant ($p < 0.001$).

A one-way Welch analysis of variance showed no significant differences in pain intensity among the lipedema stages ($F(2, 11.2) = 0.292$; $p = 0.752$). Thus, pain intensity did not differ according to disease stage. The overall reduction in pain was statistically significant ($p < 0.001$; paired-samples t-test). The extent of pain reduction also did not differ according to lipedema stage. A one-way Welch analysis of variance showed no significant association between disease stage and pain reduction ($F(2, 11.0) = 0.056$; $p = 0.946$).

Seventy-two patients tested the device for 10 days, one patient for 11 days, and 21 patients for 14 days. Information on the duration of the trial period was missing for six patients. There was no significant difference in pain reduction between trial periods of 10 and 14 days (Welch analysis of variance: $F(1, 82.6) = 0.098$; $p = 0.755$).

Forty-nine patients used the opportunity to provide free-text comments on their experience during the IPC trial period.

The most frequently reported subjective effects of IPC were pain reduction (n = 35), improved mobility (n = 15), increased diuresis (n = 14), reduced sensations of pressure and tightness (n = 13), and improved tissue quality (n = 10). Many patients also reported a sensation of bodily lightness, weight reduction, and improved skin condition (see Table 5).

Discussion

Lipedema is an illness dominated by pain in the fat tissue, pain being the “conditio sine qua non” for the diagnosis of the condition, alongside with disproportion of fat between abdomen and extremities. Newest investigations suggest a

Table 4. Pain Scores on the numerical rating scale (NRS) before and after treatment, as well as the change in pain score (difference NRS), including statistical significance of the difference.

NRS	Before	after	Difference
N	90	90	90
Missing	0	0	0
Mean	6.53	3.83	2.70
Median	6.00	4.00	3.00
Standard deviation	1.56	1.55	1.40
Minimum	3	0	0
Maximum	10	7	8
Significance before vs. after	p < .001		

Table 5. List of subjectively reported effects of intermittent pneumatic compression (IPC) on lipedema based on voluntary free-text comments, sorted by frequency of mention. The results were grouped by the author into similar contents, they were given by 49 participants.

Number of mentions	Effect
35	Less pain/pain reduction
15	Improved mobility/walking/stair climbing
14	Increased urination/fluid loss
13	Reduced sensations of pressure, tightness, or heaviness
10	Lighter legs/lighter overall body sensation
10	Improved tissue quality (softer, less hardened, less spongy)
8	Weight reduction
7	Firmer skin/improved skin quality
4	Improved quality of life
3	Better sleep
3	Reduction in edema/limb circumference
3	Reduced tenderness to pressure
2	Improved circulation
1	Reduced burning sensation
1	No longer requiring analgesic medication
1	Reduced nocturnal numbness of the hands

special adipocite migration and inflammatory component of the disease, alongside with possible neuropathic alterations.[1–3,9] Even though there is poor evidence from studies for the efficacy of compression hosiery treatment in lipedema to reduce the pain, it is at least the best studied mechanism for pain reduction.[9] It is the first line recommendation in the treatment of the pain associated with lipedema. Due to the misguiding name, "edema" suggests fluid accumulation and for a long period of time, MLD has been a standard treatment in Germany, too. Considering the high number of obese patients among the lipedema population, probably lots of them have coexistence of obesity-related lymphedema, which could be one explanation of the widespread use of MLD. The new guideline in Germany[9] does no longer recommend MLD as lipedema treatment, nevertheless, the current evaluation has 90 out of 100 patients treated with both, compression garments and MLD.

Considering the median pain level at the start of the IPC application in this group, it is obvious, that the pain level is high. Patients are very compliant with compression, which shows, that without compression hosiery, the pain level would be even higher.

Intermittent pneumatic compression (IPC) consists on boots with 12 overlapping chambers of air, which fill progressively from the feet to the groin and then deflate. This is repeated every short periods of time, depending on the device. The compression intensity is measured in mm Hg. The treatment should be at a low level, increasing in the first session until the maximum tolerated level, until values around 100 mm Hg. Depending on other conditions, like knee arthrosis, the tolerated pressure levels are different – and guidelines recommend to take the highest tolerable pressure.[12]

This is the first assessment of the subjective effects of IPC in 90 patients with lipedema who used the treatment for 10–14 days and were already receiving compression therapy and MLD. With the exception of two patients who reported no change in pain 88 patients experienced a reduction in reported pain after only 10 days of treatment. The median reduction was 3 points on the 0–10 pain scale.

It is also noteworthy that, in their free-text comments, patients did not primarily describe the effects of IPC in terms of decongestion or volume reduction. Instead, they mainly reported:

pain relief,
improved mobility,
reduced sensations of pressure, and
changes in tissue quality.

These findings are particularly relevant for patients with lipedema because these outcomes correspond closely to the symptoms emphasized in current definitions of the condition.[9] The results therefore suggest that IPC may have a clinically relevant effect on core symptom domains of lipedema like pain, pressure and impaired mobility rather than alleviating an edema that is not present.

This interpretation is also consistent with a study investigating the perceived increase in thigh circumference over the course of the day in patients with lipedema, despite the absence of an objectively measurable increase. No significant increase in thigh volume was observed in either group, and no difference in circumference measurements was found between the intervention and control groups. The authors concluded that the genuine and unpleasant sensation of increasing limb volume may be attributable to a neurogenic disturbance of the cutaneous nerves caused by the accumulation of potentially toxic substances during the day, comparable to the numb sensation experienced during local anaesthesia.[11]

The "dosage" of the IPC in form of pressure in mm Hg is difficult to standardise, as the patient has to decide the tolerated pressure level. There is no study so far comparing pressure with outcome – neither in lipedema nor in lymphedema. Until today, all the studies applied the recommended application – use the highest possible pressure. This is why in the current study the pressure levels are not evaluated, but ranged between 50 and 100 mm Hg.

The question of why pressure treatment alleviates symptoms in lipedema remains unresolved, although increasing evidence points to lipedema-specific alterations in the adipose tissue of the legs. Electron microscopy has shown that, compared with women with obesity without

lipedema and women with neither obesity nor lipedema, women with lipedema exhibit more endothelial cell plasma protrusions into the capillary lumen, a higher macrophage density in leg adipose tissue than in abdominal adipose tissue, larger adipocytes in the legs and trunk, a greater number of proliferating Ki-67-positive cells within the adipose tissue, and more calcium crystals in the adipocyte cytoplasm, which induce mitochondrial stress and stimulate collagen production.[1]

It has also been demonstrated that endothelial cells migrate from adipose-tissue vessels into the surrounding extravascular tissue, where they promote both adipocyte growth and proliferation.[2] Based on this combination of findings, it has been proposed that endothelial dysfunction, accompanied by increased inflammation and stimulation of cell proliferation and growth, may play a role in the pathophysiology of lipedema pain 3. The question remains as to why compression should be beneficial in this context.

From a mechanistic perspective, it is conceivable that external pressure reduces endothelial cell migration as well as the extravasation and distribution of pro-inflammatory mediators within the tissue. Studies investigating the effects of compression on the venous wall in chronic venous insufficiency may provide a relevant analogy. These studies initially demonstrated that, in venous insufficiency, the great saphenous vein exhibits collagen degeneration and monocyte infiltration within the vessel wall, changes that are not observed in control veins.[4] Increased levels of matrix metalloproteinases[5] and numerous additional inflammatory alterations have also been identified.[6] Compression therapy has been shown to markedly reduce inflammatory markers in the venous wall. In patients with saphenous vein insufficiency, the muscular layer of the venous wall begins to restructure within 1 week of compression therapy: new smooth muscle cells develop and intracellular vacuoles disappear.[7] If such rapid restructuring of the venous wall is possible, a comparable effect of compression on capillaries within lipedema tissue may also be conceivable. In patients with varicose veins, inflammatory markers associated with pathological changes in the venous wall decrease within 4 weeks of compression therapy, even in tributary varicosities.[8]

Thus, the pain-relieving effect of compression in lipedema may be attributable to a reduction in the migration of endothelial cells and inflammatory mediators. Given the higher pressure and greater treatment intensity associated with IPC, it is plausible to assume that the clearance of inflammatory mediators from the tissue may be further enhanced.

Considering the limited number of publications examining the effectiveness of either medical compression garments or IPC in lipedema, this study provides the first evidence from a large patient cohort of a clinically relevant reduction in lipedema-associated pain and other symptoms through the addition of IPC in a homogeneous group of patients already receiving compression garment therapy and MLD and still experiencing a high pain score.

Limitations

First, it should be noted that the patients were not diagnosed by the study physician but by the physicians who prescribed the IPC device. However, the reported high level of adherence to compression therapy and the persistently high pain scores despite compression garment and MLD suggest that the diagnosis of lipedema was likely to have been correct.

A further limitation is that the data were collected by an employee of the device manufacturer and by the patients themselves. This is unlikely to have substantially affected objective information such as height, weight, previous treatment, and disease duration. However, social desirability bias may have influenced the pain scores reported to the medical device consultant.

The observed pain reduction may also have been partly attributable to a placebo effect. IPC devices are highly sought after among patients with lipedema, obtaining reimbursement approval from health insurance providers can require considerable effort, and the additional attention and support provided by the device consultant may also have influenced the results.

Furthermore, patients were able to see the pain score they had recorded at baseline and may therefore have consciously selected a follow-up score that appeared consistent with their perceived treatment response. To reduce this potential source of bias in future studies, the medical device consultant could collect the completed pain questionnaire from day 1 and leave a separate questionnaire to be completed independently by the patient on the final day, in the absence of the consultant.

Nevertheless, the patients also provided free-text comments, and the high degree of consistency between the reported changes in NRS pain scores and the reported improvements in mobility and tissue quality supports the credibility of the findings despite the methodological limitations.

The inclusion of a control group was not possible within the present study design, as this was an analysis of patients who had actually received IPC treatment. However, the baseline pain score could be regarded as an indirect intra-individual control representing the period without IPC.

Summary

This evaluation of the amount of pain reduction after the application of intermittent pneumatic compression (IPC) in 90 patients with lipedema who were already receiving compression garment therapy and MLD showed that the use of IPC was associated with a significant reduction in self-

reported pain. This effect was independent of the now-obsolete classification into lipedema stages I–III, with patients across all stages experiencing comparable benefits. In addition, numerous patients subjectively reported improvements in mobility and tissue quality.

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Ethical considerations

The study concept was reviewed by the Ethics Committee of the Medical Association of Lower Saxony, which raised no ethical objections to the analysis of the fully anonymized dataset.

Consent to participate

The analysis was based exclusively on secondary data that had been fully anonymized by Bösl before being transferred to the author. The author had no access to directly or indirectly identifiable patient information. Patients had previously consented to the collection and processing of their data for the IPC device trial and reimbursement procedure.

Author contributions

Bösl collected the original questionnaire data and prepared the fully anonymized dataset. Erika Mendoza designed the evaluation, performed the data analysis and interpretation, and wrote the manuscript. The author had full responsibility for the final content of the manuscript.

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Declaration of conflicting interests

The author declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The study received financial support from Bösl, the manufacturer of the IPC device, and Bösl provided the anonymized dataset used for the analysis. The author declares no other competing interests.

Guarantor

Erika Mendoza

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