

# Improving the calf pump using home-based exercises for patients with chronic venous disease

When treating leg ulcers it is all too easy to lose sight of the underlying pathology and focus upon the visible ulcer. A lack of attention to the calf pump mechanism in chronic venous disease has resulted in insufficient emphasis on exercise therapy to address this neglected issue. This article focuses on what research has already been done on the calf pump and some simple practical methods which clinicians can incorporate into their strategy for venous ulcer care.

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## KEY WORDS

Venous ulcer  
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Ankle mobility  
Patient participation

Chronic venous ulcers pose a continuing challenge to nursing and interdisciplinary care. The visible nature of the ulcer wound bed makes it all too easy to focus on wound healing, while losing sight of the underlying pathology of a dysfunctional calf pump which is a major contributor to the ulceration.

This article will first focus on the literature addressing the calf pump mechanism and its inter-relationship with venous disease. It will then describe a series of exercises that patients with chronic venous ulcers can be encouraged to do in order to reduce pain and increase their range of motion (ROM), which in turn improves the calf-pump mechanism.

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These exercises have previously been discovered to be effective among this patient group (Davies et al, 2007).

## The calf pump

The calf pump is the essential mechanism by which blood is returned to the heart from the lower limbs, and is aided by the foot pump, thigh pump and respiratory pump mechanisms. Araki et al (1994) demonstrated the significance of a failing calf pump in patients with venous insufficiency progressing to ulceration. In comparing three groups of patients — active ulcers, healed ulcers and chronic venous insufficiency without ulceration — there was no significant difference in either the pattern or amount of reflux. The active ulcer group was distinguished from the other two only by means of indicators of calf muscle pump function (poorer ejection fraction and residual volume fraction). They concluded that in patients with venous insufficiency, an impaired calf pump is a key factor in the progression to ulceration.

## What biomechanical factor plays the central role in the calf pump mechanism?

Research over the past 10–12 years points to ankle joint movement as the key biomechanical element in a functioning calf pump. When artificially restricting the movement of the ankle joint in healthy volunteers, Kugler et al (2001) showed that a significant drop occurred in the efficiency of the pump to affect a decrease in venous pressure during exercise.

## How much reduction in ankle joint flexibility occurs in CVI and venous ulceration?

Back et al (1995) measured ankle range of motion (plantar and dorsiflexion) in four groups:

- ▶▶ 'Healthy' volunteers
- ▶▶ People with CVI but no ulceration
- ▶▶ People with CVI and a healed ulcer
- ▶▶ People with CVI and an active ulcer:

The study showed that a decrease in ankle range of motion occurred before any ulcer developed: a difference of an average of 57° in 'healthy' volunteers to 39° in patients with CVI but no ulcer. A steady worsening of flexibility occurred in the next two groups. Those with healed ulceration had an average of 29° ROM while those with active ulceration had, on average, only 21°. They also demonstrated that functions of calf pump efficiency (ejection fraction and residual volume fraction) correlated significantly with ankle ROM.

Back et al (1995) also showed that dorsiflexion, when measured separately, dropped from 10° in normal limbs to -5° in those with active ulceration — a total difference of 15°. This means that the average patient with an open ulcer would not be able to stand in a normal position with their feet flat on the ground when not wearing heels. Being unable to achieve a 90° angle between the foot and the ankle creates a pathological gait pattern, as normal heel to toe walking is no longer possible. The duration of ulcer

has also been shown to correspond with the loss of ankle joint flexibility. Helliwell and Cheesebrough (1994) showed that in patients with chronic leg ulceration, there was a loss of 0.78° of movement for every year of active ulceration.

**What effect does reduced ankle mobility, with its associated problems with gait and calf-pump activity have on venous ulcer wound healing?**

This is the most crucial question, and only one study by Barwell et al (2001) has focused on this specifically although other studies have looked at it more generally, in terms of reduced mobility. The study showed an astonishing difference in healing rates in patients who had less than 35° ankle ROM, compared with those with more than 35°. Only 13% of those with less than 35° had healed at 24 weeks, compared with 60% of those with more than 35°, despite all of them being treated with multilayer compression bandaging. The difference in healing rates is so significant that one would think it would have spawned a great deal of research interest, but little has been done in response.

**Are there other biomechanical factors affecting the calf pump?**

Calf muscle strength may also affect the efficiency of venous return, as improvement in calf muscle strength correlates with improved venous return, as demonstrated by Kan et al (2001). Calf muscle wasting is commonly found in patients with long-standing venous ulcers. Taheri et al (1984) demonstrated that muscle biopsies of patients suffering from venous insufficiency showed three types of atrophy occurring in the gastrocnemius muscle which suggests that disuse, denervation and ischemia all have a role to play in muscle breakdown.

How much calf muscle volume itself contributes to venous insufficiency is unclear although a recent study by Moloney et al (2007) of nine patients with venous ulceration did not show a correlation between calf muscle volume and venous return.

**Is loss of ankle mobility related to calf muscle atrophy?**

Ankle ROM is closely linked to contraction of the calf muscles and loss of flexibility may contribute substantially to disuse

atrophy as shown by Leivseth et al (1992) in their experiment on guinea pigs. When one of the legs of the guinea pigs was partially immobilised, significant muscle atrophy occurred when compared with the unrestrained leg. Immobilisation, itself, therefore, also needs to be acknowledged as a risk factor.

The fact that compression bandaging, while being absolutely necessary, can also impinge on ankle mobility needs to be recognised here. Lentner et al (1997) demonstrated on healthy volunteers that compression bandaging of different types all restrict ankle joint mobility, with thick bandages having a greater restricting effect than thinner ones.

**What gait changes occur in patients with a history of venous ulceration?**

Walking is the normal way the calf pump functions in everyday life, so gait patterns are particularly important in patients with a history of venous ulceration. This has only recently been addressed in research studies. Van Uden et al (2005) demonstrated that patients with active or healed ulcers had a slower preferred walking speed as well as taking shorter steps, though the latter did not reach statistical significance. Roaldsen et al (2006) also demonstrated a slower walking speed in active and healed ulcer patients and decreased walking endurance.

**What research has been undertaken to develop therapeutic measures to counteract musculoskeletal calf pump deficiencies?**

There are five studies into the effects of exercise on calf pump deficiencies that involve patients with chronic venous disease (Klyszcz et al, 1995; Hartmann et al, 1997; Yang et al 1999, Kan et al 2001, Padberg et al, 2004). All five reported that exercise improved venous haemodynamics, with three demonstrating an improvement in calf muscle strength. Two of the studies (Klyszcz et al, 1995; Hartmann et al, 1997) reported an improvement in the subjective experiences of the patient linked to the exercise programme — including a decrease in pain, oedema, leg restlessness and cramps, and itching.

Only two of the above studies specifically set out to achieve improved

ankle ROM: Padberg et al (2004) were unable to achieve any significant improvement after three months of supervised exercise followed by three months of unsupervised exercise. Klyszcz et al (1995) on the other hand, showed a significant improvement in patients with CVI who had moderate ankle ROM (average 34.4°). The twice-weekly intensive gym-based programme yielded a significant increase in dorsiflexion from 7.7 to 11.5° and a statistically insignificant increase in plantar flexion from 26.7° to 29°.

A pilot study by the authors (Davies et al, 2007) implemented a practical, home-based exercise programme that could be easily followed by patients unable to attend intensive gym programs. Ten patients with open venous ulceration, and who all wore compression bandaging, participated in the study. The exercise programme was done three times each week for 24 weeks, with monthly monitoring visits. Once the study was over, patients were encouraged to keep doing the exercises without supervision and a follow-up visit was done at the end of the year. The programme consisted of gait improvement and 5–10 minutes of ankle exercises carried out three times a week — if possible when the leg was unbandaged.

Ten patients took part. The median age was 73 years with a range of 63–80 years. There were four men and six women, with a median of 20 years of ulcer duration, ranging from six to 51 years. The median size of ulcer was 9.8cm<sup>2</sup>, with a range of 1.5cm to 93cm.

Two patients dropped out very shortly after screening so they were not included in the 12-week analysis. Another two dropped out at 12 weeks or later, and were therefore not included in the 24-week analysis.

The baseline mean ankle ROM for the eight patients included in the 12-week analysis was 18.5° measured using a bi-plane ankle goniometer (Figure 1) — slightly less than the average for ulcerated patients cited above by Back et al (1995). This reflected the long-term nature of the ulcers for this patient group. By week 12, there was an average increase of 8.7° (P =

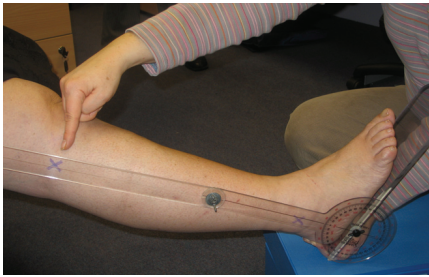


Figure 1. Bi-plane ankle goniometer.



Figure 2. Plantar flexion using the Thera-Band.



Figure 3. Dorsiflexion exercise.

0.006) to bring it to a mean of 27.2°. For the six remaining subjects who continued to 24 weeks, there was a mean change from baseline of 7.6° which translated into a mean ankle ROM of 27.1°. ( $P = 0.011$ ). The patients who had the worst mobility were found to have gained the most: the three worst-off patients had only 8–12° of ankle ROM when screened and progressed to 21–26° at week 12, an average gain of 13.7°.

Pain levels were also reduced with the median pain score for the seven patients with week 12 data being 5.5 at enrolment, and reducing to 2.0 at both week 12 and 24.

### Suggested exercise for improvements in gait and ankle ROM for patients with leg ulcers

This small, practical, home-based exercise study showed that a few minutes of simple ankle exercises each week, along with gait improvement can help to bring about a significant increase in ankle ROM and a reduction in pain. With this in mind

the exercises used in the study will be described in greater depth in the hope that clinicians can encourage patients with reduced ankle mobility to incorporate the exercises into their treatment regimens.

### Gait improvement

Patients were assessed for gait abnormalities as reduced ankle mobility, pain and compression bandaging all impinge on a normal walking pattern, with patients often adopting a shuffling type of gait. Instruction in 'heel to toe' walking was done and patients were encouraged to put the heel on the ground first, following through to the ball of the foot. This type of 'normal' gait requires active ankle movement. Some patients with very restricted ankle movement could only adopt a partial 'heel to toe' walk, but small gains were encouraged. When gait changes were being taught, the clinician always walked with the patient in case of unsteadiness, and the patient's own feeling of stability was always attended to, as changes in gait were being made.

### Ankle exercises

The exercise regimen was done with the aid of Thera-Bands™ (The Hygenic Corporation, Akron, Ohio) — a colour-coded series of graduated 14cm wide rubber bands (a non-latex band is also available for people with latex allergy). Each colour provides a different level of resistance so that patients can work their way up the bands to the most difficult.

The 5 to 10 minute regimen was undertaken three times a week. Exercises were done while seated on the edge of the chair. It was very important that they kept the knee straight and the leg angled down towards the ground because if the leg is at a 90° angle to the body this posture can cause pain in the lower back.

There were four parts to the exercise regimen:

- ▶▶ Warm-up with ankle circling
- ▶▶ Plantar flexion (Figure 2) using the Thera-Band around the ball of the foot, kept at a 50% stretch to achieve moderate resistance. Fifteen slow plantar flexions were performed against the resistance of the band. Over the next few sessions, there was a gradual increase of the number

of plantar flexions up to 25 when the patient was able to. Once 25 repetitions was achieved, the patient graduated to the next colour of band dropped back to 15 repetitions and gradually built up to 25 again. Most patients in the study graduated to the most difficult (gold) Thera-Band part way through the programme and stayed on this until the end. The aim of this exercise was to build up calf muscle, as elasticated resistance provides a slight challenge to muscles, but is still easy enough for an older patient group

- ▶▶ Dorsiflexion stretches (Figure 3) were done without the Thera-Band. Dorsiflexion is usually more compromised than plantar flexion, in patients with venous ulcers due to the tightening of the Achilles tendon. This stretch was done without the Thera-Band, as applying too much pressure in this manner to the Achilles tendon could introduce a risk of injury. The stretch has to be held for at least 10 seconds, and preferably 15 as it takes this long for the brain to register that a muscle or tendon needs to lengthen slightly. The stretch was done in the same position as the plantar flexion with the leg straight and angled towards the ground. The patient then brought their foot towards them and held the foot in this dorsiflexed position, exerting a slight stretch at the back of the calf, while counting up to 10 slowly. The stretch was repeated twice more. The need to move the ankle was emphasised as patients will often simply stretch their toes rather than the whole of the foot
- ▶▶ The fourth step was a cool down with some ankle circling.

### Recommendations for practice

Further randomised, controlled trials are needed to see whether improvement in gait and ankle flexibility correlates with increased healing and/or decreased ulcer recurrence. However, enough evidence is available from the literature to recommend that all patients with venous ulceration should have appropriate exercises incorporated into their treatment regimen, if they are willing to participate. Compression plus exercise

should be seen as the twin cornerstones of therapy for this patient group. **WUK**

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