

Compression hosiery in lymphoedema

Lymphoedema and the construction and classification of compression hosiery

Evidence for the use of compression hosiery in lymphoedema

Role of hosiery in lower limb lymphoedema



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Compression hosiery in lymphoedema

CJ Moffatt

The Lymphoedema Framework is a UK based research partnership that aims to raise the profile of lymphoedema and improve standards of care through the involvement of specialist practitioners, clinicians, patient groups, healthcare organisations, and the wound care and compression hosiery industry.

OVERVIEW

This document focuses on compression hosiery in lower limb lymphoedema.

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Although the worldwide incidence of lymphoedema has been estimated as 140 million¹, in Europe lymphoedema is perceived as a rare condition for which there is little treatment. It is becoming clear, however, that lymphoedema and venolymphatic dysfunction are relatively common and that the considerable suffering they may cause can be greatly alleviated by skilled clinicians. The *Template for Practice* series is a new educational initiative designed to raise the profile of lymphoedema and to enhance the standard of care by providing concise, relevant and highly practical information.

This issue, *Compression Hosiery in Lymphoedema*, recognises the central role that compression hosiery plays in the treatment of lower limb lymphoedema. The guidance provided is a synthesis of work undertaken by the Lymphoedema Framework with patients, clinicians and industry. The international expertise of the editorial board has now moved the guidance into the European arena.

The Lymphoedema Framework pays tribute to the work of countries such as France, Germany, the Netherlands and Spain that facilitated local reimbursement of compression garments. The Lymphoedema Framework's own guideline development has been influential in the decision of the UK Department of Health to include compression garments for lymphoedema on the UK *Drug Tariff* from 1 March 2006.

Optimal use of the diversity of compression garments requires that clinicians understand the relevance of the technical aspects of hosiery construction and the science of compression therapy. They also need to appreciate the wide ranging and complex needs of lymphoedema patients, and to adapt their therapeutic approach to provide effective hosiery that fits correctly, is comfortable and encourages long-term use.

In the first paper, Clark and Krimmel describe the basic construction of compression hosiery and how the characteristics of the fabric

contribute to the clinical effectiveness of garments. The paper then discusses the remit of compression hosiery standards, and compares different compression classifications.

The second paper outlines the evidence on compression hosiery in the management of lymphoedema. Partsch and Jünger describe the pathophysiology of lymphoedema, venolymphatic dysfunction and rebound oedema, and the mechanisms of action of compression therapy. They summarise studies of compression hosiery efficacy, and discuss the clinical implications of a new compression device parameter – 'static stiffness index'.

The final paper is a practical, decision making guide to the use of compression hosiery in lower limb lymphoedema. The paper links a new classification of compression hosiery that encompasses existing European classifications to clinical descriptions of lymphoedema. Clear explanations guide the practitioner through the processes involved in treatment with compression hosiery: the decision to prescribe hosiery; choosing the appropriate compression level, construction type and style; measuring; and checking and evaluating fit. Emphasis is placed on providing hosiery that takes a holistic view and accounts for all of the patient's needs.

We know that the evidence base for the treatment of lymphoedema is limited and much research remains to establish definitive treatment. The Lymphoedema Framework hopes that its model of working in partnership with patients, clinicians and industry will be more widely adopted, and will increase awareness of lymphoedema and further stimulate innovative product development.

By elucidating the rationale for and use of compression hosiery in the treatment of lymphoedema, this document aims to enhance practitioners' and patients' use of compression hosiery, and to transform the experience of patients with lymphoedema.

Lymphoedema and the construction and classification of compression hosiery

M Clark¹, G Kimmel²

There are many styles of compression hosiery, ranging from socks to pantyhose. The style and level of compression prescribed for patients with lymphoedema is dependent on many factors including the site, extent and severity of the swelling, the patient's ability to manage and tolerate compression, and patient choice. This article discusses the construction and classification of compression hosiery.

Lymphoedema is a consequence of impaired lymphatic drainage and can result in marked changes in the size and shape of the affected area¹. Management of limb swelling involves a variety of approaches intended to reduce localised swelling, including a specialised form of massage (manual lymphatic drainage) and the use of compression bandages and hosiery^{2,3}.

PRINCIPLES OF COMPRESSION

Where an informed clinical decision has been made to use compression garments, it is important that the skin at the site of the swelling is intact, the person wearing the hosiery can apply and remove it, and the limb size and shape allow the application of the hosiery (although this latter requirement may be negated by the use of custom made garments)¹.

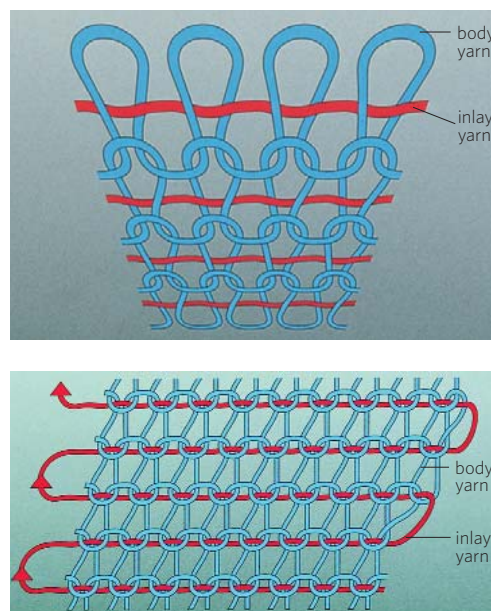
For both compression hosiery and bandages, the level of compression achieved is dependent

upon a complex interaction of the physical properties and construction of the bandage or hosiery, the size and shape of limb to which it is applied, and the activity of the wearer⁴.

As a broad principle, the level of compression is directly proportional to the tension with which the compression device is applied and is inversely related to the size of the limb – this general rule is known as Laplace's Law⁴. In compression hosiery, tension is largely determined by the materials and construction method used.

Compression bandages and hosiery are used mainly in the treatment and recurrence prevention of venous leg ulcers and apply relatively low levels of static compression to the lower leg (up to a maximum of 46mmHg applied at the ankle)⁵. However, when used as part of lymphoedema management higher levels of compression may be required, involving the use of 'very strong' compression hosiery capable of achieving at least 49mmHg at the ankle⁶.

FIGURE 1 Schematic arrangement of inlay and body yarn in knitted fabric: circular knit (top), flat knit (bottom)



HOSIERY CONSTRUCTION

The compression produced by hosiery is related to the yarn used and the technique employed to knit the yarn into the fabric of the final product.

Yarn

Compression hosiery uses two interwoven yarn systems knitted together to produce the fabric of the garment (Figure 1). The body yarn delivers the thickness and stiffness of the knitted fabric; the inlay yarn produces the compression (see Box 1 on page 4 for definitions). Inlay and body yarns are produced by wrapping polyamide or cotton around a stretchable core such as latex or elastane (Lycra) (Figure 2). The wrapping can be adjusted to vary the stretchability and power of the yarn, and the thickness, texture and appearance of the knitted fabric. Higher garment compression is mainly achieved by increasing the

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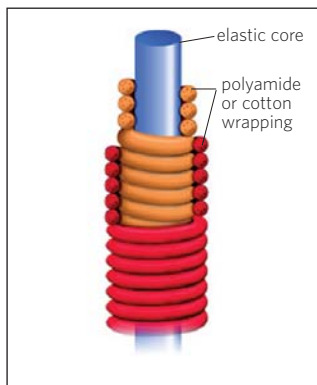


FIGURE 2 Construction of body and inlay yarn



FIGURE 3 Flat knit knee high blank (before sewing) Shaped by adding and removing needles during knitting.



FIGURE 4 Circular knit knee high garment Shaped by forming the heel and varying inlay yarn tension and stitch height during knitting.

TABLE 1 Flat knit and circular knit characteristics

	Flat knit	Circular knit
How is shape controlled?	By varying the number of needles in operation. The inlay yarn is fed in with almost no tension and does not influence the shape of the final product	Mainly by varying the tension of the inlay yarn, but also by altering stitch height; the number of needles in operation cannot be changed resulting in a limited fit range
Number of needles per inch	14-16 (coarse fabric)	24-32 (fine fabric)
Yarn thickness	Coarser - required to produce sufficient fabric stiffness and thickness	Finer - more cosmetically acceptable

thickness of the elastic core of the inlay yarn, although the body yarn may also be adjusted.

Knitting techniques

The two main knitting techniques used to produce compression hosiery are flat knit and circular knit. The type of hosiery used for the treatment of lymphoedema varies across Europe; in Germany and the Netherlands, most patients are treated with flat knit hosiery, but in the UK both circular and flat knit are used.

As its name suggests, flat knit technology results in a flat piece of fabric, which needs to be stitched to produce the final garment (Figure 3). Circular knit technology produces a tube that requires comparatively little finishing to produce the final garment (Figure 4).

Both flat and circular knit techniques are used to produce custom made and ready to wear hosiery. However, custom made garments are most often flat knit because this method of manufacture can better accommodate shape distortion. In flat knit technology, the total number of needles in use can be increased or decreased during the knitting of an individual garment to produce variations in the width and shape of the knitted piece used to construct the final garment. In circular knit technology, the number of needles in use during production of a particular garment is fixed, reducing the range of shape distortion that can be accommodated. However, some shape variation can be produced during knitting by altering the tension of the inlay yarn and, to a lesser extent, by varying stitch height.

In general, flat knit fabric is coarser than circular knit because it uses thicker yarn and consequently fewer needles per inch during knitting (Table 1). The thicker yarn produces stiffer and thicker material that is better at bridging skin folds and is less likely to cut in or cause a tourniquet effect. The finer finish of circular knit

hosiery may make it more cosmetically acceptable, but more likely to cut into the limb, particularly if worn for extended periods.

Garment care

Recommendations for the care of compression hosiery are designed to maintain hosiery performance and prolong garment life, and derive from the materials and method of construction used.

Oil-based skin cream used under hosiery may adversely affect the yarn and so affect garment performance. Ideally, garments should be hand or machine washed at the recommended temperature every day or every second day. As well as cleaning the garment, washing allows the yarns to realign after being stretched during wear and to maintain the correct compression. Hosiery should be dried away from direct contact with heat, which may be harmful to the yarn.

In general, breakdown of the elastic core due to wear means that hosiery should be replaced approximately every six months. However, for some patients, for example those who are obese or very active, heavy wear may necessitate more frequent replacement. Thicker flat knit hosiery may be more durable than circular knit.

EUROPEAN STANDARDS

National standards for compression hosiery have been developed mainly as prerequisites for reimbursement. They cover parameters such as testing methods, yarn specification, compression gradient and durability.

There are few European national standards for compression hosiery, eg British standard BS 6612:1985⁷, French standard ASQUAL⁸ and German standard RAL-GZ 387:2000⁹. Attempts were made to produce a European standard (draft standard: ENV 12718), but consensus could not be achieved and the standard was cancelled in 2005¹⁰.

TABLE 2 Comparison of hosiery classification in the British, French and German compression hosiery standards⁷⁻⁹

The mmHg ranges refer to the pressures applied at B (ankle circumference at smallest girth) by the compression hosiery.

	British standard BS 6612:1985	French standard ASQUAL	German standard RAL-GZ 387:2000
Testing method	HATRA	IFTH	HOSY
Class I	14-17mmHg	10-15mmHg	18-21mmHg
Class II	18-24mmHg	15-20mmHg	23-32mmHg
Class III	25-35mmHg	20-36mmHg	34-46mmHg
Class IV	Not reported	>36mmHg	>49mmHg

The standards describe methods used to characterise the graduated compression applied to the lower leg by compression hosiery, and focus on *in vitro* measurement of the pressures likely to be applied at various points on the limb. The compression measured at the ankle is used to classify the hosiery into compression classes I-IV. However, the pressure range used to define each class varies between the different standards, and three different techniques are used during testing to measure compression (Table 2).

Standards and limb size/shape

Even though some patients with shape distortion may require the use of custom made garments, most of the standards only consider ready to wear garments. An exception is the German standard, and in Germany custom made garments are recommended for the treatment of lymphoedema.

The national standards focus exclusively upon the characterisation of the pressures applied to the leg. There is no description within existing standards of how the compression that is applied by sleeves on the arm is to be characterised. Despite this, manufacturers offer a wide range of products for the upper limb that are clearly classified according to compression produced.

Standards and clinical guidance

Standards are of considerable value in ensuring that specific products will apply a known approximate level of compression and in providing the basis for national reimbursement strategies. However, they contain little information on the use of compression garments in the treatment of lymphoedema. This lack of clinical guidance prompted the development of guidelines in the Netherlands for the prescription and use of various forms of compression garment

in lymphoedema¹¹. Very recently, compression garments have been included on the UK *Drug Tariff* based on a new clinically-derived classification of compression hosiery that is in line with other European standards⁶.

CONCLUSION

An appreciation of how the construction of hosiery, especially knitting technique, relates to performance can assist practitioners in selecting the most appropriate hosiery for their patients.

Current national standards were developed to guide manufacturers and to classify garments according to compression produced.

Inconsistency remains across Europe in the classification of hosiery. Further development of standards could include arm sleeves and, where not already included, custom made garments.

The standards were not developed to define the complex world of oedema treatment as a whole, and the production of clinical guidelines that relate hosiery compression as defined by the standards to clinical parameters is of significant assistance to practitioners who treat lymphoedema. It is essential that practitioners remember that the pressure produced by a garment of a stated compression class during wear will be affected by many patient and practitioner related parameters.

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BOX 1 Definitions of parameters

- **Compression** – the pressure applied to the limb by the finished garment.
- **Power** – a measure of how easily the yarn stretches. Higher power yarn is less easy to stretch and will apply greater compression.
- **Stiffness** – a measure of how flexible the fabric is. Stiffer fabric is better at bridging skin folds and is less likely to cut into the skin.
- **Stretchability** – a measure of how far the yarn can be elongated. High stretchability relates to easier donning properties.
- **Thickness** – the thickness of the fabric or yarn. Thicker yarn produces thicker fabric. Thicker fabric is generally stiffer than thin fabric, but may be less cosmetically acceptable.

Evidence for the use of compression hosiery in lymphoedema

H Partsch¹, M Jünger²

Clinical practice should be founded on the implementation of evidence-based management strategies. This article draws together existing evidence for the mode of action and efficacy of compression hosiery in the management of lymphoedema and discusses the potential clinical implications of the changes in sub-hosiery pressure that occur in different limb positions and during different activities.

Hosiery is the most widely used form of compression in the long-term management of lower limb lymphoedema. However, the evidence base for compression hosiery in this condition is poor. This article, therefore, includes the findings from studies involving compression modalities other than compression hosiery and in conditions other than lymphoedema to describe the possible effects of compression hosiery on the pathophysiology of lymphoedema.

PATHOPHYSIOLOGY

Oedema occurs as a result of an increase in interstitial fluid volume. The lymphatic system is involved in all types of oedema because of its role in draining interstitial fluid. However, the term 'lymphoedema' in its strictest usage applies only when physical damage to or abnormality of the lymphatic system is associated with oedema formation¹.

Lymphatic damage may also occur in several forms of longstanding oedema. For example, secondary damage to lymphatic vessels may be seen in severe forms of venous disease (and is known as 'venolymphatic dysfunction'):

- Deep vein thrombosis and post-thrombotic syndrome are accompanied by damage to the deep subfascial lymphatics associated with the damaged deep veins².
- Physical changes in superficial prefascial lymph vessels may also be found in the region of lipodermatosclerosis and of venous leg ulcers in patients with severe chronic venous insufficiency³.

MECHANISMS OF ACTION OF COMPRESSION HOSIERY

In the management of lymphoedema, the term 'compression therapy' covers a range of treatment modalities including multi-layer

inelastic (short-stretch) lymphoedema bandaging, compression hosiery and intermittent pneumatic compression. Compression hosiery has a number of roles in the management of lymphoedema, including prophylaxis, treatment and long-term management⁴. The mechanisms and effects of compression therapy in lymphoedema that are considered most important and relevant to compression hosiery are listed in Table 1.

A major effect of compression therapy in any kind of swelling, irrespective of cause, is reduced formation of excess interstitial fluid. External compression opposes fluid filtration from blood capillaries into tissue, and thereby decreases lymphatic load. In cases with primary venous disease, compression therapy also reduces venous reflux and improves venous return. The resulting reduction of ambulatory venous hypertension reduces intravenular pressure and fluid extravasation.

The volume reduction produced by compression is mostly due to a reduction in tissue water content, with proportionately less protein removed. The relatively increased concentration of protein raises interstitial oncotic pressure, and may cause rebound oedema if external compression is interrupted⁵.

Ideally, the external pressure applied by compression hosiery should be just enough to counteract capillary filtration pressure. Since filtration pressure in the leg rises on standing, compression hosiery should exert a higher pressure in the upright position than in the supine position.

CLINICAL TRIALS OF COMPRESSION GARMENTS IN LYMPHOEDEMA

Few randomised controlled clinical trials have investigated the role of compression therapy (garments or bandaging) in the management of

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TABLE 1 Mechanisms and effects of compression therapy in lymphoedema

Mechanism	Effect
Increased interstitial pressure	Reduced capillary filtration ⁶⁻⁸ and production of lymph; limb volume decrease
Shift of fluid into uncompressed areas	Proximal volume increase accommodated by normally working lymphatics in that region and assisted by manual lymphatic drainage ⁹
Increased lymph reabsorption and stimulation of lymphatic contractions	Improvement of lymph kinetics as shown by lymphoscintigraphy ¹⁰ and intralymphatic measurement of flow and pressure ^{11,12}
Breakdown of fibrosclerotic tissue	Softening of tissue as shown by ultrasound ¹³ and durometer ¹⁴
Improvement of venous pump in patients with venolymphatic dysfunction	Increased expelled blood volume; reduction of venous reflux and ambulatory venous hypertension ¹⁵

lymphoedema. An international consensus conference in 2003 that concentrated on evidence for compression therapy identified four randomised controlled trials of lymphoedema management¹⁶. One trial compared compression bandaging with compression garments¹⁷; the others investigated the efficacy of adjunctive treatments such as manual lymphatic drainage or electrostimulation¹⁸⁻²¹. A more recent study investigated the effects of manual lymphatic drainage in postmastectomy lymphoedema being treated with compression bandaging²².

Compression garments versus compression bandaging

In the only trial that has compared compression bandaging with compression garments, 83 patients with primary or secondary lymphoedema of lower or upper limbs were treated either with multi-layer bandaging

followed by compression stockings or sleeves, or with stockings or sleeves alone. Bandaging followed by compression garments produced a greater and more sustained reduction in limb volume than did compression garments alone¹⁷.

Compression garments in long-term management

Several follow-up studies have demonstrated the efficacy of compression garments in different types and anatomical locations of lymphoedema.

One study showed that oedema of the arm after mastectomy was reduced by 17% when elastic sleeves were worn for a period of between one week and up to six months. Subsequent treatment by intermittent pneumatic compression for ten days produced an additional significant volume decrease of 18%. Relapse was prevented by further treatment with compression sleeves²³.

A long-term (mean follow-up 25 months) clinical benefit achieved by compression stockings has been shown for patients with primary and secondary lymphoedema²⁴. Studies with follow-up periods of six months to five years indicate that compression garments are effective in reducing and/or maintaining lymphoedema of the arm and leg^{25,26}.

There is localised lymphatic damage in lipodermatosclerosis of the distal lower leg due to venous insufficiency. As a result, lipodermatosclerosis may be taken as a model of localised lymphoedema^{3,27,28}. Using high frequency ultrasound, Gniadecka and coworkers demonstrated that class I and class II compression stockings (defined as 18-26mmHg and 26-36mmHg respectively) successfully reduced oedema in lipodermatosclerosis²⁹. In

FIGURE 1 The effect of compression hosiery on lymphatic function in lipodermatosclerosis²⁷

Indirect lymphography using intradermal infusion of a water-soluble contrast medium into a lipodermatosclerotic skin area due to severe chronic insufficiency shows irregular initial lymphatics and extravasation of the dye into the tissue (left). After 2 years of wearing a 30-40mmHg compression stocking, normal lymph collectors are filled and no extravasation is seen (right).



BOX 1 Questions for future studies on lymphoedema

- At different levels of compression, however applied, what degree of oedema reduction can be expected in the first and following weeks of initial treatment:
 - for the lower extremity?
 - for the upper extremity?
 - for the head/neck/trunk/breast/genitalia?
 - during the day?
 - at night?
- Which compression technique and which materials achieve optimal results in initial treatment and long-term management?
- What degree of oedema reduction can be expected with hosiery alone?
- What pressure is needed to limit rebound swelling in long-term management?
- What benefits can supplementary treatment modalities provide, and how should they be used for greatest benefit?

BOX 2 Static stiffness index (SSI)

The increase in interface pressure that occurs on standing up from lying down.

addition, long-term treatment with compression hosiery has been shown to completely normalise the pathology of the initial lymphatics in lipodermatosclerotic skin (Figure 1)²⁷.

The importance of long-term compression therapy in lymphoedema has been clearly demonstrated by several authors^{24,26,30,31}. However, the necessity of lifelong maintenance compression therapy in lymphoedema is not always reflected in practice. Some years ago, a survey on the use of pressotherapy in France revealed that only 43.5% of physicians used elastic support following active treatment sessions³². Experience today suggests that compression hosiery remains underused in lymphoedema for a number of reasons, including underprescribing and issues relating to patients' ability to tolerate and manage hosiery.

Future studies

Further studies are needed to clarify the mechanisms of action of compression therapy and the optimal treatment regimens (Box 1).

Essential to the effective investigation of these issues are tools and methods that:

- measure the pressure produced by compression bandaging or hosiery

- assess the performance of compression modalities and materials *in vivo*.

INTERFACE PRESSURE AND STATIC STIFFNESS INDEX

Interface pressure is the pressure produced by a compression system on the skin's surface. It can be measured by placing a pressure transducer between the compression system and the limb. Interface pressure increases when limb circumference rises due to muscle contraction. Materials that are less elastic are stiffer and produce greater variations in interface pressure³³.

When measuring interface pressure, the pressure transducer is placed at the site of greatest increase of limb circumference during muscle contraction. In the leg, this is over the point where the medial gastrocnemius muscle becomes tendinous and is called B1 by the hosiery manufacturers (Figure 2)³⁴.

An increase of leg circumference at this site can be achieved by dorsiflexion or by standing from the supine position. It has been proposed that the pressure rise that occurs from lying to standing becomes a parameter called the 'static stiffness index' (SSI) (Box 2)³⁵. Elastic (long-stretch) material, as used in compression hosiery, has a lower SSI than the inelastic (short-stretch) material used in multi-layer lymphoedema bandaging³⁵. However, SSI increases when several layers of stocking are applied over each other³⁶.

Sub-bandage pressure changes

The effect of inelastic or elastic bandaging on lower leg interface pressure at B1 in different body positions and during different activities in a patient with venous ulceration is presented in Figure 3. With inelastic bandaging, the resting interface pressure at B1 in the sitting position is 48mmHg (Figure 3a). With repeated dorsiflexion during sitting, pressure peaks of 80mmHg are seen. When the patient stands, the pressure rises from 50mmHg to 72mmHg. During tiptoeing the pressure fluctuates between 45mmHg and 80mmHg, and during knee bends between 60mmHg and 90mmHg.

The resting pressure in the sitting position with elastic bandaging is 51mmHg (Figure 3b). When the patient stands, a modest rise occurs to about 59mmHg. The fluctuations during exercise are much less pronounced than those seen with

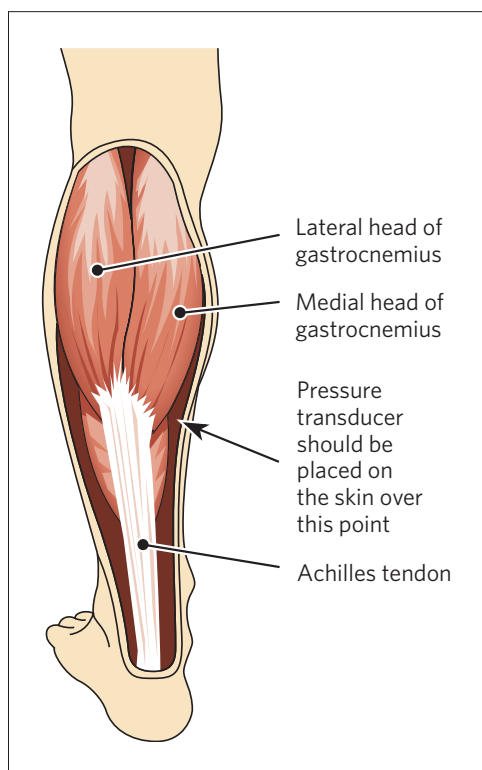


FIGURE 2 Pressure transducer positioning for measurement of interface pressure Pressure transducer should be placed on the skin over the point where the medial gastrocnemius muscle becomes tendinous – this corresponds to B1 level for compression hosiery fitting.

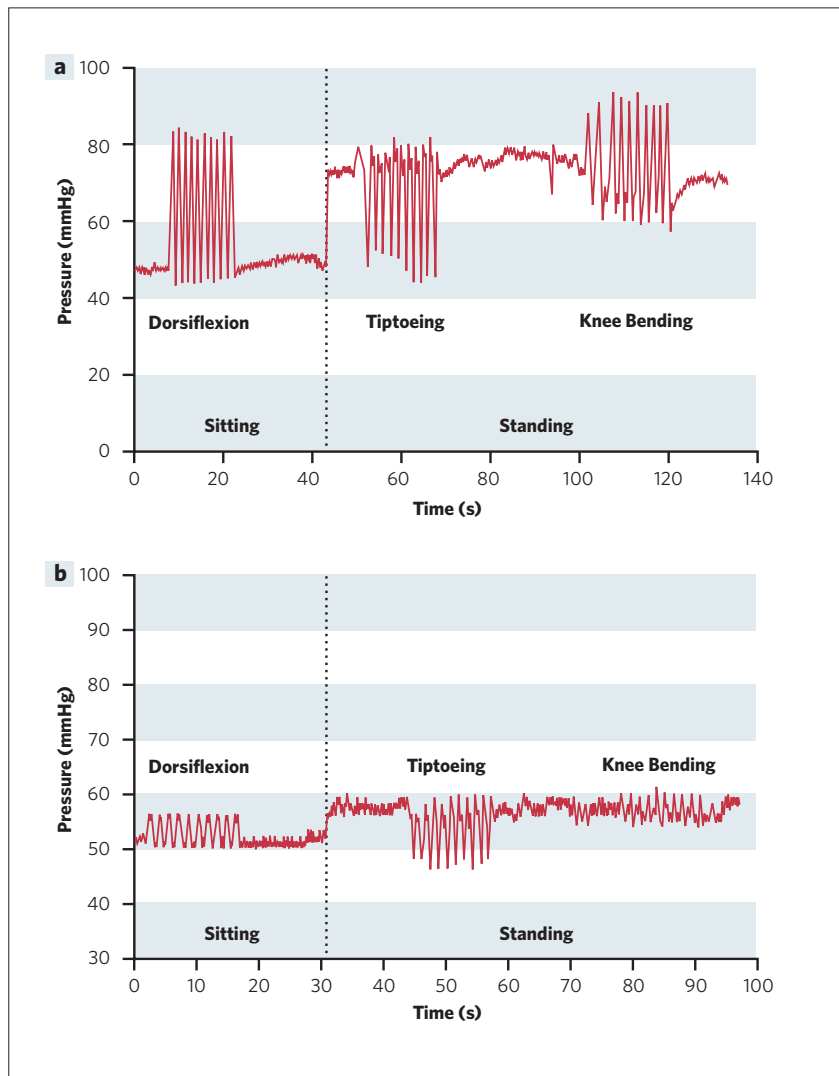


FIGURE 3 Interface pressures in the lower leg produced by (a) inelastic bandaging and (b) elastic bandaging

inelastic bandaging. The figures tell us that the pressure in the upright position is 22mmHg higher than in the supine position for the inelastic material, but only 8mmHg higher for the elastic material³⁶. This greater difference between sitting and standing interface pressure seen with the inelastic bandaging suggests that inelastic material may be better able than elastic material to compensate for the increased hydrostatic pressure that occurs in the upright position. Inelastic material would therefore be expected to have a more pronounced effect on reducing oedema formation than elastic material³⁷.

Potential physiological effects

In chronic venous insufficiency, it has been shown that increased SSI, as indicated by high

working to resting pressure ratio, correlates with improved venous haemodynamics^{38,39}. Furthermore, the greater pressure variations and higher amplitudes produced by inelastic material during walking also have major effects on the release of vasoactive mediators from the endothelium⁴⁰. For patients with lymphoedema, it may be speculated that these pressure peaks also influence the contraction of lymphangions, which react to intermittent stimuli like arterial pulsation, respiration and massage. The optimal range of these pressure fluctuations is not known and it is possible that the lower pressure peaks achieved by compression stockings may have similar effects.

Implications for compression hosiery

The choice of compression hosiery type for an individual patient is influenced by many patient- and disease-related factors, and as yet there is no definitive evidence supporting the choice of hosiery of a particular construction. However, these findings suggest that using hosiery with a higher SSI, ie flat knit garments, may have some possible advantages in lymphoedema and should be further investigated.

Today a wide range of ready made flat knit compression garments is available. It should be noted, however, that the range of ready made circular knit hosiery has increased greatly recently and clinical experience suggests that in the early stages of lymphoedema some patients can be treated successfully with these products. In cases with severe shape distortion, the relatively elastic circular knit garments may not fit properly causing pain, skin damage and a tourniquet effect, and making custom made flat knit hosiery the only solution.

CONCLUSION

Despite limited evidence for compression hosiery in the treatment of lymphoedema, it is a widely accepted and important part of management. Findings from studies involving other compression modalities, particularly multi-layer inelastic lymphoedema bandaging, indicate principles that might be applied to the use of compression hosiery.

Sustained pressure levels that increase on standing and pressure fluctuations during walking appear to be important actions of

compression therapy in the treatment of lymphoedema. These properties of compression therapy systems relate to their SSI. Therefore, future studies on compression therapy in lymphoedema, including the role of compression hosiery, should relate outcome parameters (such as volume decrease and patient-related outcomes), to *in vivo* measures of interface pressure and SSI.

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Role of hosiery in lower limb lymphoedema

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As part of its work to establish national provision of lymphoedema services in the UK, the Lymphoedema Framework project has developed guidelines for the use of compression hosiery in lower limb lymphoedema. The guidelines presented in this article have drawn together existing hosiery classifications and linked a new classification with clinical descriptions of lymphoedema. The article provides clear guidance on practical aspects such as assessment of arterial status and measurement for hosiery, and describes strategies for addressing problems that may be encountered.

Compression hosiery plays a pivotal role in the management of lymphoedema. However, systematic reviews have revealed a lack of robust evidence to support treatment decisions^{1,2,3}. The Lymphoedema Framework project in the UK recognised the lack of empirical evidence and consequently adopted a rigorous consensus approach to defining best practice⁴. The recommendations that emerged for the use of compression hosiery in adults with lower limb lymphoedema, or related conditions such as phlebolymphoedema and lipoedema, form the basis of this paper. They emphasise that patients require hosiery that meets their clinical *and* lifestyle needs.

Compression hosiery enhances selfcare and can be used in the management of all clinical stages of lower limb lymphoedema⁵. Its main role is in long-term management, usually following a period of intensive treatment (skin care, exercise, multi-layer inelastic (short-stretch) lymphoedema bandaging ± manual lymphatic drainage)⁶. However, hosiery can also be used to prevent complications in subclinical and very early lymphoedema, and following intensive therapy with bandaging⁷.

AN ALGORITHM FOR DECISION-MAKING IN COMPRESSION HOSIERY

The algorithm on page 16 summarises the recommendations, which are patient focused and designed to promote flexible decision-making. Importantly, they include the need to assess arterial status in order to ensure safety, particularly when high levels of compression are being considered⁸. Clear clinical descriptions of the different stages of lymphoedema⁹ are related to recommendations for the type of hosiery to use and the role of other compression modalities.

To use the algorithm effectively, practitioners must be skilled in assessment and be able to define the type and severity of lymphoedema. Appropriate training is required to ensure skilled measurement and fitting, and an understanding of the range of hosiery and materials available¹⁰. Access to specialist intervention will be required for patients with severe complex lymphoedema.

CLINICAL FACTORS INFLUENCING THE USE OF COMPRESSION HOSIERY

The suitability of compression hosiery for a patient is influenced by a number of factors (Box 1). Practitioners should take these factors into account to ensure that garments are comfortable and offer an appropriate level of compression that helps to control swelling.

Dexterity

Application and removal of compression hosiery requires considerable dexterity and strength. The high compression hosiery that may be used in lymphoedema may be challenging.

Patients who have severe arthritis may find application and removal particularly difficult. Grossly obese patients may be unable to reach their feet, and patients with complex medical conditions such as heart failure may be unsuitable for hosiery because the extra exertion may exacerbate their symptoms (it should be noted that acute heart failure is a contraindication to compression hosiery)¹¹.

Patients may require aids to assist application or removal, and some patients may find flat knit compression hosiery easier to apply than circular knit. Where patients cannot manage their hosiery, carers should be taught the necessary skills and shown how to monitor limb condition. Patients who find hosiery

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BOX 1 Patient factors influencing suitability for compression hosiery

- Ability to manage and tolerate hosiery
- Skin condition
- Lymphoedema stage and severity
- Shape, size and function of the limb
- Patient build, eg tall, short, obese
- Lower limb arterial status
- Concomitant medical conditions, eg neuropathy
- Patient lifestyle, mobility, age and psychosocial status
- Patient choice

removal difficult should be discouraged from only partially removing their garments by pulling them down to their ankles. Patients and carers should be warned that incomplete removal of hosiery can cause a tourniquet effect and tissue trauma if the garment becomes doubled over or is rolled.

Practitioners should be able to modify their choice of material, style of garment and level of pressure to overcome these issues.

Skin resilience

A common problem that may complicate the use of compression hosiery is poor skin resilience and quality. If the skin is very fragile, trauma can easily occur. Skin problems including varicose eczema and lymphorrhoea can be treated by appropriate skin care regimens and the use of cotton liners beneath compression hosiery. If eczema and lymphorrhoea are severe, hosiery may be inappropriate and a period of intensive treatment involving bandaging may be required to stabilise the condition.

During an episode of cellulitis compression hosiery is not usually tolerated. It may be possible to continue compression using reduced pressure multi-layer inelastic (short-stretch) lymphoedema bandaging (MLLB). If pain is too severe, it may be necessary to stop compression therapy. However, long periods without compression should be avoided. Once the pain and inflammation are sufficiently reduced and the patient is able to tolerate it, the usual level and/or mode of compression should be resumed.

Skin sensitivity and allergy can occur in a small proportion of patients to some components within hosiery, including latex, elastane and dyes¹². Allergy can be avoided or resolved by using cotton liners to prevent direct contact with the skin or by changing to a different product.

Poor measurement and fitting, and inappropriate choice of hosiery may lead to tissue trauma, even in patients with intact skin.

Shape distortion

Ready made hosiery may be suitable for patients with minimal shape distortion. For patients with severe shape distortion, a period of intensive treatment may be required to normalise shape before hosiery can be prescribed⁶.

Most patients with shape distortion are better treated with custom made flat knit hosiery, which does not curl, twist or tourniquet. Flat

knit hosiery is often stiffer and so is more likely to prevent rebound oedema. Compression hosiery can be modified to accommodate shape distortion by using fillers and shaped pads under or built into the garment.

Patients with shape distortion and swelling extending into the genitalia and trunk will require specialist intervention to ensure the appropriate selection and fit of garments.

Containment of swelling by compression hosiery

In some patients, lymphoedema is not contained by compression hosiery alone, and concomitant use of therapies such as bandaging at night and manual lymphatic drainage may be required.

The needs of the palliative patient are complex. In some cases, treatment emphasis may shift from containment of swelling to provision of comfort and improvement in quality of life. It may be necessary to use hosiery with reduced levels of compression and/or utilise alternative garments, eg close-fitting shorts with Lycra (such as cycle or running shorts) or shaped elasticated tubular bandage, to provide compression. Bandaging may be the preferred option for those palliative patients whose symptoms preclude the use of compression hosiery.

Ability to monitor and self manage

Patient engagement and commitment are essential foundations for effective self management¹³. Factors that influence self management include beliefs about the condition and psychological factors that may affect motivation, eg depression and anxiety. Access to social support may be of critical importance.

Concordance is enhanced by appropriate patient education and affected by a number of practical issues¹⁴. Fit, style and material influence appearance, comfort and willingness to persevere with treatment. Patients must be able to wear comfortable footwear with their hosiery to facilitate mobility.

Additional instruction, support and monitoring may be required for patients with cognitive impairment to ensure that they wear garments appropriately and that skin problems are avoided. Similarly, patients with neurological impairment (eg stroke, spinal injury or spina

BOX 2 Choosing the appropriate compression hosiery style**Toe caps**

- Lymphoedema of the toes (Figure 1)
- Following treatment of lymphorrhoea or interdigital mycosis
- Forefoot swelling and risk of or presence of toe swelling
- Tissue thickening in the forefoot – toe caps will provide additional pressure and reduce slippage of an open toe garment up the foot

Below knee*

- Swelling and skin changes limited to below the knee
- Venous ulceration without thigh swelling
- Inability to apply full length garment
- Obesity

Thigh length*

- Swelling extending to thigh
- Papillomatosis on medial aspect of thigh
- Fat or arthritic knees (Figure 2)
- Limb distortion
- If below knee hosiery cuts into the skin and other causes, eg inaccurate measurement, have been excluded

Pantyhose*†

- Swelling extending to genitalia or abdomen‡
- Full length hosiery does not stay in place

*Open toe hosiery is easier to apply than closed toe and may be sufficient for mild forefoot swelling. If toe caps are impractical and toe swelling is mild, closed toe hosiery may be preferable to open toe. Flat knit is often preferred for treating swelling of the forefoot.

†Incontinent patients requiring pantyhose may benefit from flat knit custom made open gusset garments.

‡Bermuda shorts may be useful in patients who have lymphoedema of the thigh secondary to an abdominal tumour without swelling of the lower leg.



FIGURE 1 Swelling of forefoot and toes Treatment with toe caps and below knee hosiery would be the preferred treatment for this patient.

bifida) and their carers need to be vigilant because warning mechanisms, such as pain, may be compromised.

Assessment should also take into consideration problems of toileting, the presence of a colostomy, and the ability of the patient to remove and reapply hosiery. Skin excoriation may occur under compression garments in patients with incontinence. Many of the hosiery needs of larger patients can be addressed by using custom made garments. Grossly obese patients present a complex challenge in terms of fitting appropriate hosiery that they are able to apply and remove and will usually require custom made hosiery. Pronounced skin folds can become excoriated and develop fungal infections.

Ability to tolerate compression hosiery

An individual's willingness and ability to tolerate therapeutic levels of compression should be considered and garment choice modified when necessary.

Assessment of the general health status of the patient is integral to decision-making¹⁵. Compression hosiery moves fluid from the

peripheral circulation to the central circulation and may precipitate decompensated heart failure in patients with cardiac oedema¹⁶.

MEASUREMENT FOR HOSIERY

Accurate measurement is essential for correct garment fit and optimal patient comfort. Badly fitting hosiery may not contain the lymphoedema, may cause tissue damage, may be uncomfortable and poorly tolerated, and may dissuade the patient from wearing hosiery long-term.

The type of hosiery prescribed will be strongly influenced by the site and extent of the swelling, but must also take into account the patient's comfort, lifestyle, preferences and ability to apply and remove garments. Patients may require a range of garments to wear in different situations.

Ready made or custom made?

Once full assessment has indicated the need for hosiery, the appropriate style (Box 2) and type of hosiery should be determined. Patients with complex lower limb and torso lymphoedema will often require custom made garments. In general, custom made flat knit hosiery may be required when there is severe shape distortion, when different levels of pressure are required within the same garment at different anatomical sites, or when special adaptations are required.

Flat knit hosiery may be easier to apply than circular knit, and where layers of hosiery are to be combined, application may be aided by using a flat knit garment next to the skin with a circular knit garment on top. Patients may express a preference, eg for a particular garment style, for the more open weave of flat knit garments in hot weather or for the more aesthetically acceptable thinner material of circular knit garments. Therapists should take patient preference into consideration when determining optimal therapy, while encouraging patients to have the most appropriate treatment.

When to measure

Measurement for hosiery should take place when any intensive therapy has been completed and the limb is in the best possible condition with stable limb volume and minimal or no residual pitting oedema. If soft pitting oedema is present, treatment with compression bandaging is



FIGURE 2 Arthritic knees in patient with lower limb lipolymphoedema This patient may find a two piece combination, eg overlapping Bermuda short style compression garment and below knee stockings, easier to manage. An orthopaedic knee support may help to relieve knee pain.

advisable before garment measuring⁶. The skin needs to be robust enough to withstand garment application and removal.

After measurement, bandaging should be continued until the time of garment fitting, otherwise rebound oedema can occur, sometimes within a few hours of discontinuation.

For patients already wearing compression hosiery, measurement should take place:

- prior to garment renewal to ensure that the correct size of garment is being prescribed and that deterioration is not occurring
- if the patient is moving from ready made garments to custom made garments or vice versa
- if a different style of garment is required
- if adaptations to the hosiery are required or a different garment pressure is required.

Overcoming practical difficulties

Measurement can be difficult in patients with

complex lower limb lymphoedema who are often immobile and obese.

In the clinic situation, measurement of the limb can be performed with the patient lying on a couch or standing. Where possible, use of a measuring board is recommended.

Patients who are wheelchair bound can be measured with their legs in a dependent position. However, if a thigh length garment is required, measurement on a couch is recommended.

The tension applied by the practitioner to the tape during measurement for compression hosiery will be influenced by the therapeutic effect desired, the age of the patient, the ability of the patient to tolerate compression and the patient's peripheral arterial blood supply.

It is essential that practitioners are fully trained in measurement and fitting and have the relevant clinical experience. Specialist advice and measurement is required in patients with limb distortion or swelling involving the abdomen and the external genitalia.

NOTES Boxes 3-5

- These boxes provide a guide to measuring for compression hosiery. Careful attention should be paid to the measuring instructions of the manufacturers from which garments are ordered.
- Measurement must be performed by those who are adequately qualified. This may include lymphoedema practitioners, specialist pharmacists or orthotists.

BOX 3 Measuring for ready made compression hosiery

For below knee garments

- Take measurements in lying or standing position
- Measure the circumference of the ankle at its smallest diameter, usually just above the malleoli
- Measure the circumference of the calf at its greatest girth
- For closed toe garments: measure foot length from the tip of the big toe to the end of the heel
- For open toe garments: measure foot length from the base of the big toe to the end of the heel
- Measure length from heel to 2cm below popliteal fossa to determine whether the patient requires standard, petite or longer length fitting

For above knee (thigh length) garments

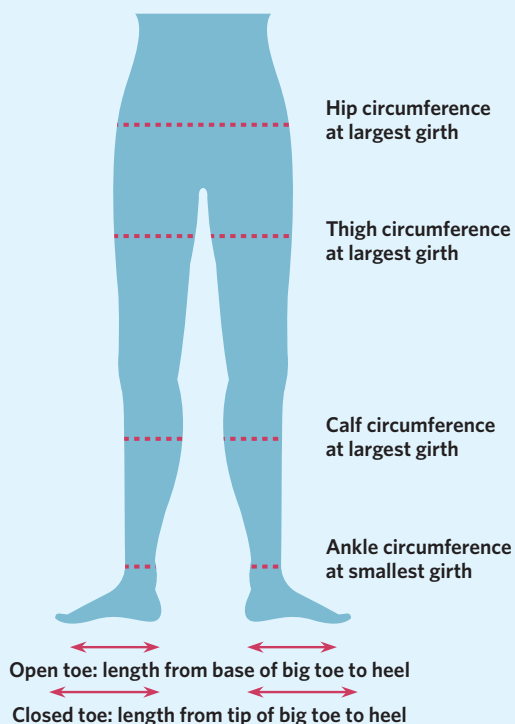
Measure as for below knee and:

- Measure the circumference of the thigh at its greatest girth
- Measure length from heel to where garment is to finish to determine which hosiery length is required

For pantyhose

Measure as for below knee and above knee and:

- Measure circumference of hips at their greatest girth



BOX 4 Measuring for custom made compression hosiery

For below knee garments

- Take measurements in lying or standing position
- For open toe garments: measure length from the base of the big toe to the end of the heel along the side of the foot
- For slanted toe garments: also measure length from the base of the little toe to the end of the heel along the side of the foot
- For closed toe garments: measure length from the tip of the big toe to the end of the heel along the side of the foot
- Measure circumference A around the base of the toes
- Measure circumference H around the instep and heel when the foot is dorsiflexed. If the patient is unable to dorsiflex, measure H and add 1cm
- With the foot against the floor or a measurement board, measure circumference B at 2cm above the medial malleolus
- Measure length a-B (from heel to B)
- Measure circumference B1 where the calf starts to widen, and measure length a-B1
- Measure circumference C and length a-C at the widest girth of the calf
- Measure circumference D at 2cm (two finger widths) below the knee cap and length a-D

For above knee (thigh length) garments

Measure as for below knee and:

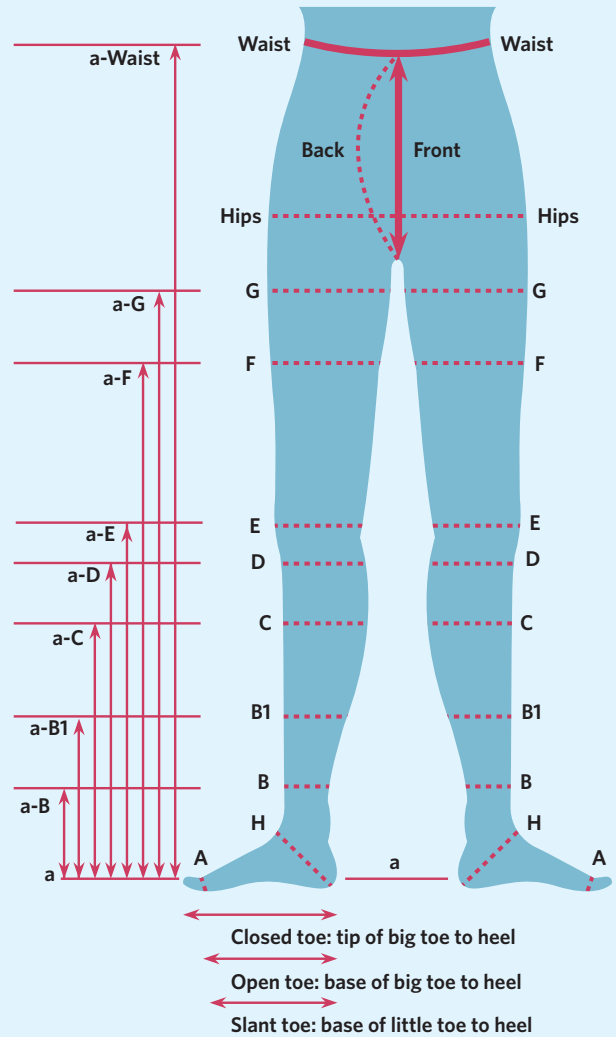
- Measure length a-E to the middle of the knee cap with the leg extended
- Measure circumference E over the knee with the leg slightly bent
- Ask the patient to stand if possible
- Measure circumference F at mid-thigh and measure length a-F
- Measure circumference at maximum thigh girth (G)
- Measure length from a to 2cm below the gluteal fold (G) for thigh length garments

For pantyhose

Measure as for below knee and above knee garments and:

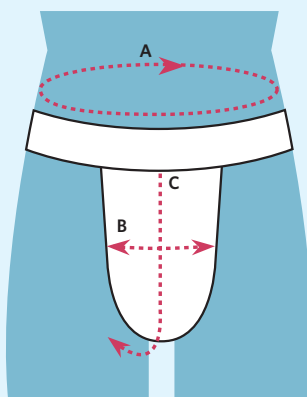
- Measure length a to 2cm below the gluteal fold (G)
- Ask the patient to put their hands on their waistline. Measure length from a to the waistline
- Measure waist circumference
- Measure greatest circumference around the hips
- Measure length in the centre at the front from waist to crotch. If the abdomen is soft, apply gentle pressure to this area during measurement to mimic the action of the garment
- Measure length at the back from the waist over the buttocks to the gluteal fold while applying gentle pressure

NB: Unless specified, length measurements should be longitudinal and should not follow body contours.



BOX 5 Measuring for scrotal support garments

- If possible, measure while the patient is standing
- Ask patient to indicate on the waist where they want the scrotal support waistband to sit
- Measure circumference A of the waist at this point
- Measure circumference B at the widest part of the scrotum
- Measure length C from indicated waistband position over the scrotum to the perineum



ASSESSMENT OF ARTERIAL STATUS

The first decision within the algorithm concerns the patient's arterial status, and aids the practitioner in choosing a safe and appropriate level of compression for the stage and severity of lymphoedema.

Palpation of pedal pulses is very difficult in lymphoedema and is also a poor predictor of arterial status¹⁷. Assessment of arterial status should use Doppler ultrasound to determine ankle to brachial pressure index (ABPI) (Box 6). Recording ankle pressures may be difficult to achieve in patients with severe lymphoedema. A larger cuff size and change of Doppler probe to a lower frequency may enable measurement¹⁸.

BOX 6 Recording ankle brachial pressure index (APBI)

Recording an ABPI is essential to ensure that patients with lower limb peripheral arterial occlusive disease are identified: high compression in these patients may cause tissue ischaemia and result in amputation. However, the reliability of recordings in patients with lymphoedema is unknown and clinical judgement should be used in determining a patient's suitability for a particular level of compression.

The lower resting pressure of flat knit hosiery may be preferable in patients with lower limb peripheral arterial occlusive disease²⁰.

- **ABPI >0.8:** High compression (34-46mmHg) is considered safe for ABPI >0.8. Very high compression (49-70mmHg) may be used in selected patients with ABPI >0.8¹⁹. However, patients should be encouraged to monitor their limb for signs of ischaemia such as altered sensation or colour, or pain. If there is any concern about the patient's arterial status, high and very high compression should not be commenced without specialist clarification.
- **ABPI 0.5-0.8:** Compression hosiery can be used in moderate peripheral arterial occlusive disease (ABPI 0.5-0.8). Reduced levels of compression will be required and will be significantly influenced by the patient's tolerance of compression. Rigorous monitoring is required to detect symptoms of ischaemia – these patients have established occlusive arterial disease that can deteriorate rapidly. Compression up to 21mmHg can be considered in this group.
- **ABPI <0.5:** Compression therapy should not be applied to patients with ABPI <0.5 because it may exacerbate tissue ischaemia; all patients should be referred for a vascular assessment and monitoring. Very low levels of compression may be used in some of these patients under close vascular supervision.

In patients with diabetes mellitus or where there is considerable oedema and/or tissue thickening (fibrosis), ABPI may produce unreliable readings; toe brachial pressure index (TBPI) may provide a more accurate evaluation of the patient's peripheral arterial status (Box 7). In some centres, duplex scanning or plethysmography may be used.

At present, the prevalence of peripheral arterial occlusive disease in patients with lymphoedema remains unknown. However, since

prevalence rises with increasing age and many patients are asymptomatic¹⁹, it is likely that some older patients will have a degree of concurrent arterial impairment. Assessment of peripheral arterial status is therefore of particular importance in older patients being assessed for compression hosiery.

The recommendations used in this algorithm (see page 16) reflect international guidelines on the use of compression in patients with varying degrees of peripheral arterial occlusive disease²⁰.

BOX 7 Measuring toe brachial pressure index (TBPI)

Note: TBPI should only be performed when ABPI is not possible. See Vowden and Vowden (2001) for a description of how to perform ABPI (see Further reading, page 21).

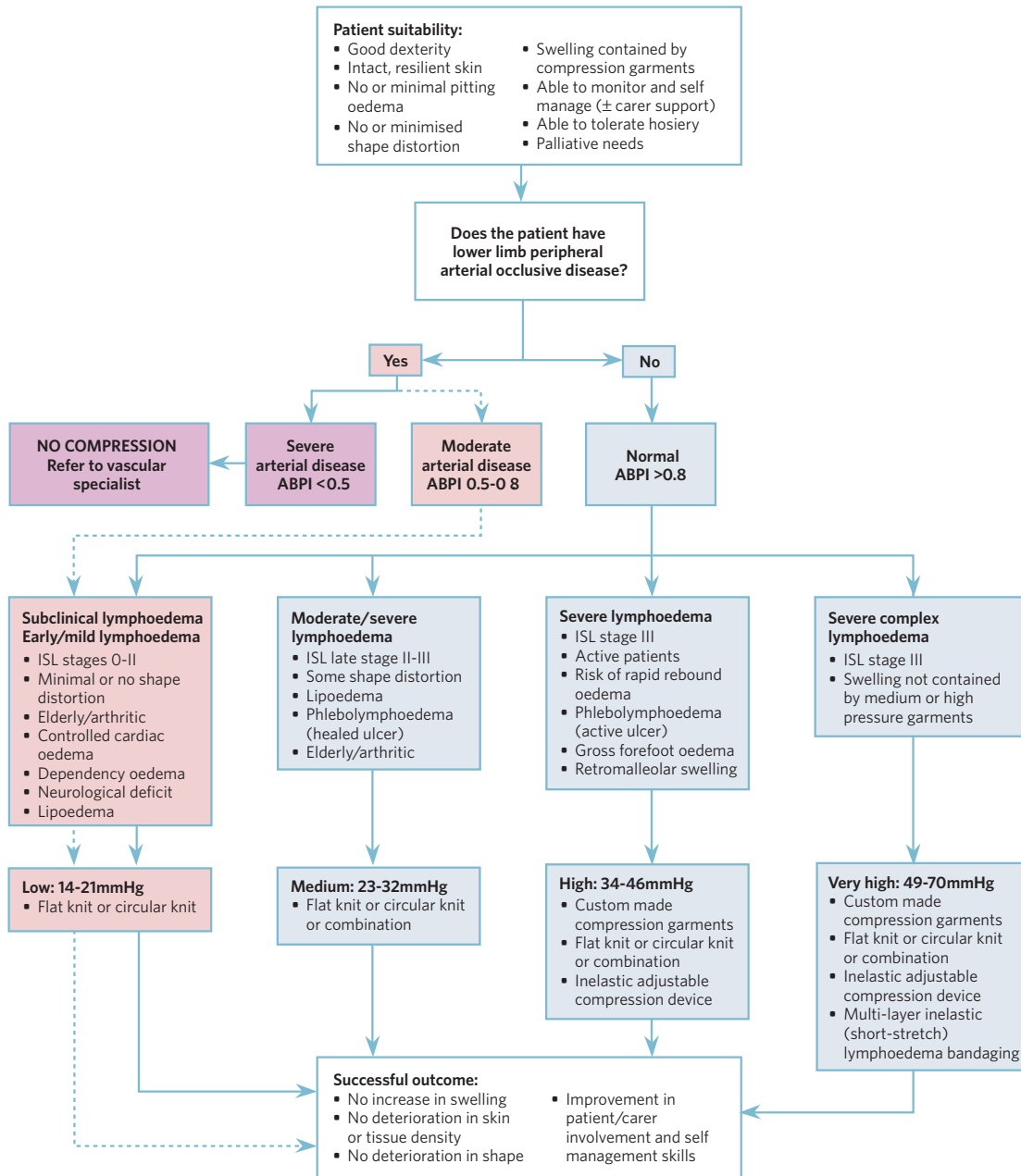
- Lie the patient as flat as possible for 15-20 minutes and explain the procedure
- Place the appropriate size sphygmomanometer cuff around the arm and apply gel over the brachial pulse
- Move the Doppler probe over the brachial pulse until a good signal is obtained
- Inflate the cuff until the signal disappears, then gradually deflate until the signal returns. This is the brachial systolic pressure. Repeat
- Repeat using the other arm and record the highest of the four brachial readings (the highest brachial reading is used to calculate the TBPI for both legs)
- Place an appropriately sized toe cuff around the base of the big toe
- Apply gel and locate the digital artery using the Doppler probe
- Inflate the cuff until the signal disappears, then gradually deflate until the signal returns. This is the toe systolic pressure
- Repeat the process and record the highest of the readings
- Repeat to measure the highest toe systolic pressure in the other leg

Calculate TBPI for each leg:

$$TBPI = \frac{\text{highest toe systolic reading for that leg}}{\text{highest brachial systolic reading}}$$

TBPI <0.64 indicates the presence of lower limb peripheral arterial occlusive disease





International Society of Lymphology lymphoedema staging⁵

Stage 0	Stage I	Stage II	Late stage II	Stage III
A subclinical state where swelling is not present despite impaired lymph transport. This stage may exist for months or years before any oedema becomes evident.	This represents early onset of the condition where there is accumulation of tissue fluid that subsides with limb elevation. The oedema may be pitting at this stage.	Limb elevation alone rarely reduces swelling and pitting is manifest.	There may or may not be pitting as tissue fibrosis is more evident.	The tissue is hard (fibrotic) and pitting is absent. Skin changes such as thickening, hyperpigmentation, increased skin folds, fat deposits and warty overgrowths develop.

FIGURE 3 Algorithm for decision making in compression hosiery, adapted from²⁴ This algorithm is a guide and treatment should be tailored to the needs of the individual patient. If the patient is unable to tolerate the therapeutically indicated level of compression, lower levels of compression may be appropriate to encourage concordance with hosiery. The tolerability of high levels of compression may be enhanced by using flat knit hosiery.

RECOMMENDATIONS FOR COMPRESSION HOSIERY IN LOWER LIMB LYMPHOEDEMA

The precise pressure and stiffness of materials required for compression in different degrees of lymphoedema have not been determined. However, the pressures used are generally higher than those used to treat venous disease, and higher pressure is required for increased lymphoedema stage and severity⁷. Physiological research and clinical expert opinion recommend graduated compression hosiery that delivers sub-hosiery ankle pressures of 20-60mmHg²¹.

Several classifications have been developed based on the level of compression applied by hosiery^{22,23}. These recommendations seek to bring these classifications together to provide clear guidance on the use of hosiery in primary and secondary lower limb lymphoedema (Figure 3).

Subclinical lymphoedema (low: 14-21mmHg)

Although the true potential for using compression to prevent complications and deterioration in subclinical lymphoedema has not been fully examined, low levels of compression (14-21mmHg) are recommended in patients who are known to be **at risk** of developing lower limb lymphoedema. Ideally, patients should wear their hosiery all day.

Early/mild lymphoedema (low: 14-21mmHg)

Mild lymphoedema is characterised by pitting oedema that can subside, and has also been defined as <10-20% excess limb volume when compared to the unaffected limb⁵.

Low compression may be used in the very early stages of **primary lymphoedema** when skin changes are absent. If there is pitting oedema, one or two sessions of MLLB (± manual lymphatic drainage) may be required before hosiery fitting. Careful monitoring is required to ensure that the pressure applied is sufficient to prevent deterioration. Many patients with primary lymphoedema will require much higher levels of compression over time to prevent tissue changes, increased limb volume and limb distortion.

Elderly patients with arthritis can often manage to apply and remove hosiery of this compression level. While the control of oedema may not be optimal, even a low level of compression is better than none.

Patients with lymphoedema and **stable cardiac disease** benefit from low levels of compression and should be monitored carefully: a change in symptoms such as breathlessness on exertion may indicate imminent cardiac failure.

Immobile patients who sit for long periods with their legs in a dependent position are prone to developing oedema even if lymphatic or venous disease is minimal. Low levels of compression may contain the swelling.

Low pressure is indicated where compression may cause skin damage in the presence of **neurological deficit**.

For unknown reasons, patients with **lipoedema** frequently suffer pain with compression. Low pressure may be tolerated sufficiently to allow any co-existing oedema to resolve.

Moderate/severe lymphoedema (medium: 23-32mmHg)

Moderate to severe lymphoedema is characterised by tissue thickening (fibrosis) and predominantly nonpitting oedema, with an excess limb volume of 20-40%. In severe lymphoedema, excess volume is >40%⁵. Deepened skin folds, fat deposits and warty growths are frequently present.

Patients with **venous ulcers** have locally disturbed lymphatic drainage, and reduced subfascial lymph transport is seen in deep vein thrombosis or post-thrombotic syndrome¹⁶. Although in patients with a healed ulcer and lymphoedema, a pressure of 40mmHg is recommended, medium compression (23-32mmHg) is often sufficient to prevent deterioration. If ulceration recurs, higher compression may be required.

Some patients with **lipoedema** and concurrent lymphoedema may be able to tolerate this higher level of compression.

Elderly or arthritic patients with reasonable dexterity are often able to apply a garment providing a pressure of 23-32mmHg. Alternatively, these patients may wear two lower pressure garments one on top of the other to achieve the desired pressure. The additional garment applies about 70% of the pressure it would exert if applied alone²⁴.

Some **elderly patients** with moderate/severe lymphoedema may only be able to tolerate pressures of 14-21mmHg. However, in some cases it may be possible to increase this to

CAUTIONARY NOTE

In a few patients with ISL stage III lymphoedema, it has occasionally been observed that the medically desired level of compression causes tissue hardening and exacerbates rebound oedema. In such cases, a reduction in the level of compression may be necessary.

23-32mmHg by using flat knit garments, which may be stiffer than circular knit and provide comparatively low resting pressures²⁵.

Severe lymphoedema (high: 34-46 mmHg)

Severe lymphoedema is characterised by hard, thickened tissue with minimal or undetectable pitting. Excess limb volume may be >40%⁵. Skin changes such as hyperkeratosis, hyperpigmentation, deepened skin folds, fat deposits and warty growths are common. Increased severity may be accompanied by other problems, eg fragile skin, lymphorrhoea, ulceration and increased frequency of cellulitis. Shape distortion can be severe, often impairing limb and overall function.

High compression (34-46 mmHg) is required for **severe lymphoedema**, and is particularly suitable for active patients and those at risk of rapid rebound oedema at lower compression.

Elderly patients with severe lymphoedema may be best managed by combining layers of low and medium compression hosiery.

In line with other international recommendations, patients with an **active venous ulcer** require this high level of compression^{20,26}.

High compression is also required following treatment for **gross forefoot oedema** that overhangs the toes and for **retromalleolar swelling** with tissue thickening. Where toe swelling has occurred, custom made flat knit toe caps may be required. High pressure levels may make application difficult and combinations of flat and circular knit hosiery are often useful. All patients require well fitting, supportive shoes that help control oedema and aid mobility.

Severe complex lymphoedema (very high: 49-70mmHg)

Very high compression (49-70mmHg) is reserved for patients with **severe complex lymphoedema**. Many patients with **primary lymphoedema of long duration** require this level of compression to control their condition and prevent complications.

A particularly complex group are those described as '**resistant**' to medium and high compression²⁴. The use of stiffer flat knit material may allow oedema to be contained while enabling patients to tolerate very high compression levels. Such high levels of

BOX 8 Tips for checking fit

On first application, check that the:

- ordered garment meets specification of prescription
- garment fully covers the area requiring treatment
- material of the garment is evenly distributed with no folds, wrinkles or tight bands
- garment is comfortable and is not too tight or loose
- attachments or fixations are comfortable and keep the garment in place.

Additionally at follow up:

- Assess patient motivation and use of the garment
- Check that the garment:
 - stays in place and that there is no slippage requiring a need for or a change in fixation
 - does not cause skin reactions or localised skin trauma
 - is not folded back at the top, and has not been cut or reshaped
- For below knee or thigh length garments - check for swelling above the area covered by the garment
- For open toe garments - check for slippage up the foot causing strangulation

BOX 9 Information for patients

To use garments effectively, patients need to know:

- how compression hosiery works to control lymphoedema
- how to care for their skin - to apply emollient at night; to use a cotton liner to protect the garment if emollient is applied just before donning, the skin is at risk of trauma or there is dermatitis
- when to wear hosiery and the importance of wearing hosiery each day, including during exercise*
- how and when to apply the garment - in particular to remove all wrinkles, to avoid overstretching the garment by pulling too far up the limb, not to fold the garment down at the top, to apply the garment in the morning when the limb is least swollen
- to wash the garment frequently following the manufacturer's instructions and to dry it away from direct heat
- who to contact if the skin appears chafed, cut or discoloured or if pain, pins and needles or peripheral swelling develop
- how to monitor their swelling and who to inform if there is deterioration.

*During swimming, patients may choose to wear an old garment. Current garments should not be used because chlorine will damage the fibres.

compression tend to be used on larger limbs with good skin condition and in younger patients.

Custom or ready made flat knit hosiery is usually recommended for this group. However, custom or ready made circular knit hosiery is also available. The application over hosiery of an inelastic adjustable compression device to the



FIGURE 4 Poorly applied hosiery causing proximal swelling



FIGURE 5 Circular knit hosiery caused cutting in at the ankle



FIGURE 6 Toe swelling

BOX 10 Application aids

- Ribbed rubber gloves
- Anti-slip mats
- Silk slippers
- Metal applicators

BOX 11 Keeping garments in place

- Skin glue
- Silicone band at top of garment (must not cut in or cause swelling)
- Waistband
- Half panty
- Full panty

foot and lower limb may be useful where control of swelling is poor. If garments of such high levels are difficult to apply or tolerate, patients may use a combination of hosiery and MLLB, or layering of garments to achieve adequate control of swelling.

Very high levels of compression should always be used with caution because of the risk of compromising the circulation. A specialist therapist should initiate hosiery and teach MLLB for use when hosiery is not worn.

FITTING AND EVALUATION

An appropriately trained practitioner should check the fit of a newly prescribed compression garment (Box 8) and ensure patients have the information they need to use their hosiery effectively and appropriately (Box 9). The practitioner should also demonstrate garment application and removal, and check that the patient or carer is able to perform these tasks. Application aids (Box 10) and strategies to prevent garment slippage (Box 11) may be necessary. Patients should be reviewed four to six weeks after initial fitting²⁵, and then after three to six months if fit and response to compression are satisfactory. During reassessment, practitioners should seek to understand the patient's perspective of their progress and integrate this with their own, ensure that the level of compression is adequate, and evaluate the patient/carer's ability to manage the hosiery and care for the affected limb (Figure 4).

Particular attention should be paid to the presence of pain, which may indicate a problem such as ischaemia, infection or deep vein thrombosis. Patients should be evaluated to ensure that hosiery does not cause damage to the foot and ankle. Circular knit garments can cut into these areas causing a tourniquet effect (Figure 5), tissue damage and entrapment of oedema. Flat knit garments may be useful if these are particular problems. If deterioration does occur, practitioners must reassess the patient to determine whether there is a change in overall health status and to explore whether there are issues affecting the patient's ability to self manage, eg access to carer support. Practitioners should then consider whether an adaptation of the compression hosiery is required or whether a period of intensive treatment involving manual lymphatic drainage and MLLB will improve the situation.

The successful outcomes set out in the algorithm are indicators of effective compression and a level of self management that supports and maintains improvements in the affected limb.

Garment renewal

The need for replacement garments should be reviewed every three to six months, or when they start to lose elasticity. Very active patients may need replacement garments more frequently.

PROBLEM SOLVING

Careful thought is required in the use of compression hosiery in lymphoedema of the feet to ensure that the garments do not exacerbate concomitant problems or hamper mobility. Many elderly patients have co-existing foot problems such as neuropathy or claw toes. Patients frequently develop callus, particularly if they have altered gait or foot deformities, and it is important that this is regularly debrided by a podiatrist.

Toe swelling

Custom made flat knit toe caps may be required for lymphoedema of the toes (Figure 6). However, less dextrous patients or those who find it difficult to bend down may find toe caps fiddly to apply. A closed toe garment may be more appropriate.

Forefoot swelling

Open toe garments may be easier to apply than closed toe garments, and are sufficient when there is no risk of toe swelling. Closed toe garments are useful if there is mild toe or forefoot swelling, particularly in the elderly who may be unable to apply toe caps. A flat knit garment may give better control of forefoot oedema than circular knit.

In patients with lymphoedema of the foot only, an inelastic foot wrap can be used to contain swelling and reduce tissue thickening. The pressure applied by the device can be varied by altering the tension of the fixing straps. This device and a full leg inelastic adjustable compression device may be particularly useful in elderly patients who cannot apply hosiery and in whom rebound or dependency oedema is a significant problem.



FIGURE 7 Forefoot bulge



FIGURE 8 Fungal infection in a skin fold



FIGURE 9 Stasis pad for retromalleolar bulge prior to application of hosiery



FIGURE 10 Patient with lower limb deformity causing widened gait and eversion of the feet

Forefoot bulge

A custom made flat knit garment may be required to apply sufficient pressure to forefoot bulge (Figure 7). Additional pressure can be applied with a foam pad that has been cut to size and had its edges bevelled. The pad is held in place beneath the hosiery by a retaining bandage.

Manual lymphatic drainage may be used to assist with reduction of oedema and tissue thickening in this difficult area. An inelastic adjustable foot wrap may be a useful addition to hosiery or manual/simple lymphatic drainage.

It is important to check that footwear does not exacerbate forefoot bulge. Supportive well-fitting shoes play an important part in swelling reduction and control.

Overhang of lymphoedema at the ankle

Overhang of tissue folds around the foot is common in lower limb lymphoedema. Before hosiery can be used, patients will require treatment with MLLB. Protective foam pieces can be placed between the skin folds to protect the skin from pressure damage when hosiery is applied.

Care must be taken to ensure fungal infections do not proliferate in skin folds (Figure 8). If a fungal infection does occur, it may be necessary to discontinue hosiery while the infection is treated and continue compression with bandaging.

Retromalleolar bulge with thickened tissue

Foam pads can be applied to the retromalleolar area to apply appropriate local pressure and to reduce underlying tissue thickening (Figure 9). These can be worn under hosiery, incorporated into custom made garments during manufacture, or can be inserted into pouches that were stitched into the hosiery when it was made. Foam can be cut and moulded around the malleoli to help prevent ulceration in patients with venous disease and lymphoedema.

Hallux valgus and bunionettes

Closed toe garments are preferable in patients with hallux valgus or bunionettes as the band from an open toe garment may put pressure on these areas. Alternatively, slant toe hosiery may be helpful. Application of pressure-relieving adhesive foam can prevent skin trauma or friction over the vulnerable area.

Fat/arthritis knees

Hosiery without fixation bands (cuffs) helps to prevent rolling and accommodates fat or arthritic knees. Skin glues may help prevent hosiery slippage. A range of ready made hosiery is available in a variety of styles and sizes, including for extra wide calf. However, custom made flat knit hosiery is frequently required due to the extreme limb distortion.

Crescent shaped or foam chip stasis pads can be used to focus pressure on thickened tissue on the front of the leg below the patella. If necessary, instead of using thigh length hosiery, the stasis pads can be held in place with an orthopaedic elasticated knee support combined with an overlapping below knee garment.

Foot deformities and gait abnormalities

The shape distortion that may occur as a result of lower limb lymphoedema may affect mobility and gait (Figure 10). Practitioners should always assess patients' walking to evaluate any abnormality of gait and determine the need for physiotherapy referral. Custom made shoes may be necessary if gait deformity is severe, and may also help to control forefoot oedema. If the gait abnormality is associated with pain in the hips or knees, further investigation may be required.

TRUNCAL AND GENITAL LYMPHOEDEMA

International recommendations for the pressure required for compression to the trunk do not exist. However, clinical experience suggests that pressures in excess of 25mmHg are required to treat swelling in these areas.

Truncal oedema and genital oedema (Figures 11 and 12) frequently co-exist with severe lower limb lymphoedema. The groin is a difficult area to compress and may require management with combinations of hosiery. One legged or two legged pantyhose angled across the groin with a closed gusset may be helpful. Pendulous lobes should be supported and padded with individually tailored foam pieces. Tailor made foam padding can be inserted over the mons pubis beneath compression garments. For men with scrotal swelling, supportive garments can be used including scrotal supports. If high pressure is not tolerated, supportive cycle shorts may be helpful.



FIGURE 11 Postsurgical female genital lymphoedema
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FIGURE 12 Male patient with genital lymphoedema and unilateral lower limb lymphoedema The scrotal swelling is suitable for a scrotal support garment.
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An increasing range of specialist compression garments is available for patients with truncal and/or genital lymphoedema.

CONCLUSION

Compression hosiery continues to play a major role in the treatment of lower limb lymphoedema. Measurement for hosiery should take place when pitting oedema is minimal or absent. The final choice of hosiery should take account of the wide range of patient-related and lymphoedema-related factors discussed in this article.

Further research is required to assess the clinical and cost effectiveness of compression hosiery in different patient groups. This will allow future recommendations to be based on empirical research as well as the important knowledge gained from practitioners.

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