Journal of Engineering and Technology
of the Open University of Sri Lanka (JET-OUSL), Vol. 3, No.2, 2015, ISSN 2279-2627

A study about the Lock-Out Point of Bandages Used for Compression Therapy

R.A.Manawacharitha[1], W.A.Wimalaweera[1*] and S. M. Wijeyaratna[2]

[1]Department of Textile and Apparel technology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka
[2]Department of Surgery, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka

*Corresponding Author email: wawim@ou.ac.lk, Tel: +94112881411

Abstract - *Compression bandages appear as the simplest, cheapest and most common compression devices used in the compression therapy. There is a wide variety of compression bandages in the market and they are differing from each other in several ways. To achieve the required different levels of pressure the bandage materials must be provided with some characteristics. One important characteristic is the lock-out behavior. The lock-out point is defined as the point at which physical structure of the bandage prevents further noticeable extension with increasing load when it is under tensional load. It is evident that the term lock-out is not properly defined and all the commercially available bandages do not exhibit a well defined lock-out point.*

Under the present project load/elongation behavior of 10 different woven, warp-knitted and leno-woven bandages were investigated and their lock-out ranges were identified. The differences in lock-out behavior are discussed in relation to structural parameters. A new geometrical construction method is introduced to locate lock-out point of different bandages with lock-out ranges of different width.

All the investigated bandages exhibit similar load/elongation behavior but with different lock-out ranges amounting from 28% to 85% elongation. The narrowest lock-out range was exhibited by a so-called short stretch-bandage. Warp-knitted bandages made of elastic and non-stretch yarns in the warp have relatively wide lock-out ranges amounting to 70% elongation. These bandages fall in to the category of long-stretch bandages. However a bandage with non-stretch warp but with leno weave has the widest lock-out range amounting to 85% elongation.

Key words: *compression therapy, bandages, load/elongation behavior, lock-out point*

1 INTRODUCTION

Compression therapy is used very successfully for the treatment of edema and other venous disorders of the lower limb. Presently stockings, bandages and intermittent pneumatic compression devices are employed to treat venous leg ulcers. Compression bandages appear as the simplest, cheapest and most common compression devices used in the compression therapy.

Three distinctive interface pressures between the bandage and leg are identified as important in deciding the effectiveness of the compression system. These three key pressures are the resting pressure (pressure sustained upon application of compression bandage – also known as supine pressure), the load pressure (pressure during standing) and the working pressure (pressure during walking). To promote pumping of blood upwards these three pressures are in a relationship with low resting pressure, to high load pressure and to the highest working pressure. To achieve these three levels of pressure the bandage material must be provided with some characteristics. A bandage which is very easily stretchable will provide a sufficient resting pressure at a relatively long stretch but will not be in a position to produce sufficient load and working pressures at practically lower limb contraction amounts. The material must have certain stiffness to produce sufficient pressure levels during standing (Partch, 2005a).

A bandage which does not have a sufficient stretch at supine position will not sustain the supine pressure if the limb circumference is reduced in few minutes after the application due to the displacement of tissue fluid under the compression (Partch, 2005b). To meet these requirements the bandages must have a load / elongation behavior with a low elastic modulus and a high stretch during application and a high elastic modulus above the level of tension/elongation which produces the supine pressure.

A point at which physical structure of the bandage prevents further noticeable extension with increasing load is identified as lock-out point in the literature. This point is also used by the practitioner to decide the tension at which the bandage is applied. However the lock-out point is not well-defined for any commercially available bandage. There is no evidence in the literature about any method suitable to locate the lock-out point in the load/elongation curve. According to Templeton (2009), inelastic (Short-stretch) bandages ideally lockout at 30-40% stretch but some may not lockout until 70% stretch. Long stretch bandages do not lockout until about 140% stretch. Most probably, these values have been estimated based on extensions reached during application of bandages.

The objective of this paper is to understand the term “Lock-out” by studying the load elongation behaviour of bandages of different structure and to discuss its importance. Further a geometrical construction method is proposed to locate lock-out point in the load/elongation curve of a bandage. Lock-out elongations and lock-out tensions are determined for all the bandages investigated under the present project. Interrelationships between lock-out tension/elongation and elongation at 10 N/cm load is discussed with the aim of evaluating the validity of the presently used bandage classification.

2 LITERATURE SURVEY

Compression therapy is the cornerstone of treatment for venous or lymphatic disorders. Generally compression implies deliberate application of pressure to the limb to get desired clinical effect. ‘Therapeutic limb compression is used to prevent edema formation, to reduce existing edema, and to prevent re-accumulation of edema once it is reduced. Forms of therapeutic compression for limb edema, lymphoedema and venous leg ulcers include compression bandaging, pneumatic compression and compression garments (stockings/sleeves)’ (Mayrovitz, 2004). Compression bandages and compressin garments are pure textile products.

There is a wide variety of compression bandages in the market and they are differing from each other in several ways. The differences can be observed in raw material type, fabric formation method, physical properties and the nature of pressure developed. These differences have led to a classification of compression bandages. The classification of compression bandages as "long-stretch" and "short-stretch" is very common in the compression therapy literature. A bandage material with a maximum extension of greater than 100% is called 'elastic or long-stretch bandages'. A bandage material with a maximum extension of less than 100% is called short-stretch bandages; short-stretch and un-stretchable bandages are usually called inelastic bandages (Partch et al., 2008 and Moffatt, 2005). The use of the terms elastic and inelastic to identify bandages with high and low stretch is rather questionable. The extensibility of bandages is measured in laboratory tests and expressed as a percentage of the original length. Extension of any material can be divided into 'elastic' and 'plastic' extension. Elastic extension is the extension which is recovered after the load applied is removed while plastic extension means permanent change of shape. It is not correct to assume that the bandages with higher stretch are more elastic than those with a lower level of stretch.

Further what is understood by maximum extension is not very clear. It is definitely not the breaking extension. However it is evident from some other literature that a stretch at a load of 10 N/cm width is used for this type of classification (Partsch, et Al., 2008).

According to Mosti et al., 2009 'short-stretch' bandages are of early stretch (under a low tensile load) and further extension becomes difficult above a certain limit of load. This extension is known as 'lock-out extension'. However, it appears that even the so-called long stretch bandages can show a behavior similar to lock-out but at a higher stretch and over larger range elongation. It is necessary to investigate about the elongation level and range of percentage elongation over which lock-out takes place.

A bandage material that contains a higher percentage of elastic material behaves in a manner similar to a stretched spring. Elastic or long-stretch bandage contains a higher percentage of elastic yarns (Mosti et. Al., 2009). However, this statement is not well substantiated. The stretch-ability of a bandage with stretch (elastic) yarns and non-stretch (inelastic) yarns depends also on the crimp of the non-stretch yarn in the case of the woven materials or on the loop structure of the non-stretch yarns in the case of knitted fabrics.

The bandage stretch is proportional to the reactive tension and this causes radial directed 'resting' pressure. The elastic yarns display very little plastic deformation and hence remain in a sustainable compression. Here the term 'resting' is used to distinguish a pressure in a muscularly relaxed limb from a dynamic pressure which is resulted by muscular contraction. A bandage material with small percentage of elastic material exerts much less resting pressure on the limb (Mosti et. Al., 2009).

Short-stretch bandages and long-stretch bandages are functioning in two different ways after the application. 'The long-stretch bandages provide sustained constant compression and the cohesive/adhesive or short-stretch bandage offer rigidity and enhances the calf muscle pump function by developing different levels of pressure under different conditions' (Marston and Vowden, 2003).

Elastic (long stretch) materials expand or contract to accommodate changes in leg muscle expansion during the usage. Short-stretch materials resist the expansion of limb muscles and increase the interface pressure (Mosti et al, 2008). This statement is only partly correct, because even a long stretch bandage can provide an increased standing and working pressures if they are mad to have a higher elastic modulus at and above the application elongation. Important is the load elongation behavior of the bandage material in the lock-out range, at which the bandage is applied to the limb. Mosti et al, (2008) mentioned further "One important difference between elastic (long stretch) and inelastic (short stretch) bandages when both are applied with the same supine pressure, is the high pressure increase in the upright position and during exercise with inelastic in contrast to elastic material. Even when both bandages are applied with the same standing pressure inelastic material shows a significantly higher pressure increase during exercise compared with elastic material". This statement shows that the behavior of the bandage at the application tension/elongation is the decisive factor.

According to Mosti et al., 2008, long-stretch bandages generate higher resting pressure on the limb after the application and it can be hazardous to the patient especially at bed rest. We can therefore conclude that an elastic (long stretch) bandage exerts a pressure sustained upon different conditions. This means that we can produce a very strong pressure in the standing position with this elastic bandage provided it is applied at a very high stretch. However, such a bandage will also exert a very high pressure in the supine position which make the bandage intolerable and which should be avoided in the clinical setting (Mosti, 2010).

In the literature, the term long-stretch is used as a synonym to elastic and short-stretch is used as synonym to non-elastic. Sometimes the term lock-out is used only in the case of short-stretch bandages. There is a need to clarify the use of these terms and this paper intends to identify bandage types with respect to the load / elongation behavior at lock-out region.

3 METHODOLOGY

Ten (10) different types of bandages available in the Sri Lankan market were analyzed for the important fabric structural parameters and tested for load elongation behavior.

Tinus Oleson Tensile Strength Tester available in the research laboratory of the Department of Textile and Apparel Technology was employed for testing of the tensile behaviour. Testing machine was set for an elongation rate of 100 mm/min and the gauge length was 10cm. All the fabric samples were subjected to a maximum tensile load of 10N per cm width and a 0.1N was applied as the pre-load.

All the tests were performed under standard atmospheric conditions (65±2% relative humidity and 270±20C temperature), and the samples were conditioned under same condition for 48 hours before testing. 5 K BS 4952; 2.4. Extn. & Rec. [Variable Setting] software was adopted for the evaluation of load extension behaviour.

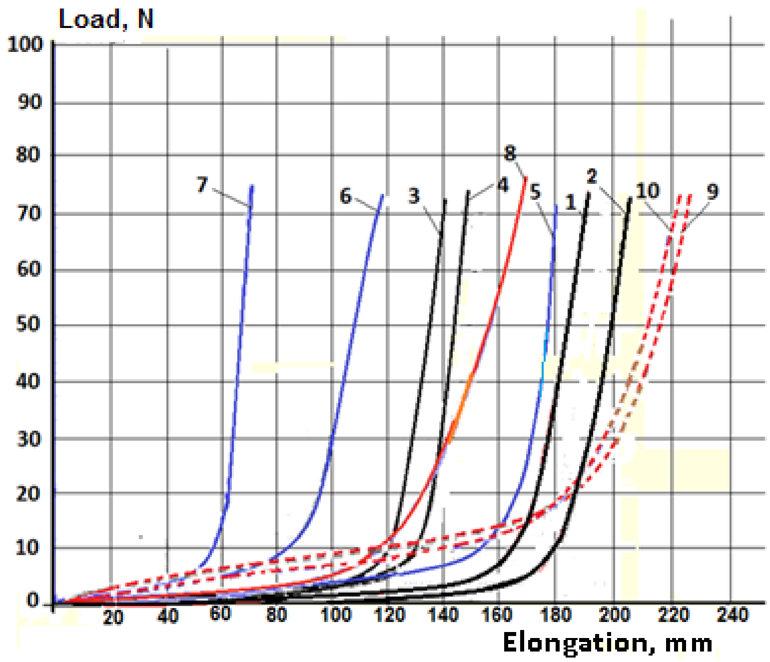
All the load/elongation curves were analyzed to determine lock-out regions. Lock-out points were located using a method suggested in this project.

4 RESULTS AND DISCUSSION

First of all let us formulate a new definition to the lock-out point or lock-out region and then look at the lock-out behaviour of different types of bandages.

4.1 Lock-out point of bandages

The term "lock-out point" is found in some research papers on load elongation behaviour of compression bandages. The lock-out point is defined as the point at which physical structure of the bandage prevents further noticeable extension with increasing load. The load/elongation curves (Fig. 1) do not exhibit any exact lock-out point but a region over which the elastic modulus changes from a very low value to a higher value. In the load/elongation curve, initially the elastic modulus is very low and then changes it rapidly to reach a very high constant value. (It should be noted that this low constant modulus of elasticity is not the initial modulus elasticity.) The lock-out region lies between these two linear regions of the load/elongation curve. Lock-out point is a point on the load / elongation curve in this region. Hence, looking from a more technical point of view we can define "the point at which the elastic modulus changes from a low constant value to a very high constant value as the lock-out point". However we can also use the term lock-out region (or range) because in all the commercially available bandages a point at which the elastic modulus changes from a lower constant value to a very high constant value can't be identified.



[*Bandage fabrics represented by different numbers 1 to 10 are listed in the column 1of the table 1.*]

Figure 1 Load/Elongation curves of 10 different bandage fabrics

The tension achieved at lock-out extension is the tension prevailing in the bandage once the bandage is applied because the person applying the bandage has no other way to decide the application tension/elongation other than stretching it to the maximum possible length which is easily achievable. Therefore lockout tension of a bandage determines the resting pressure (supine pressure).

Standing pressure is higher than the supine pressure as limb dimensions increase when a person stands-up from the resting position. The working pressure is the highest and it is expected to change depending on the change of limb dimensions due to muscle contractions and expansions during walking. All these pressures depend on the load elongation behaviour of the bandage in the proximity of the lock-out point (range). Therefore the bandages with narrow lock-out regions are expected to behave better producing lower tension while the patient is resting and sufficiently increased tensions during standing and walking. To achieve this, the difference between the elastic moduli before and after the lock-out also must be sufficiently large. The bandages with wider lock-out ranges may result in a defined supine pressure as the person applying the bandage has difficulties to control the required elongation due to not well defined lock-out point.

Lock-out ranges of the tested bandages (as percentages of elongation) are tabulated in the Table 1. The bandages with two types of warp yarns, namely 100% cotton staple yarns and Cotton or Nylon covered spandex, have a lock-out ranges between 35%-40% elongation (Bandages 1 to 4, Table 1). In the case of fabrics with covered spandex only in the warp, the lock-out range can be as narrow as 28% and wide up to 60% (Bandages 7 and 5). Warp knit fabrics with different multi-filaments yarns and rubber threads have very wide lock-out ranges of 70% elongation while a plain leno woven bandage with non-stretch cotton warp yarns exhibit the widest lock-out range of 85%.

Table 1 Structural properties, lock-out range and lock-out point of the tested bandages

Sample number, Weave, Finish	Warp type and sett, 1/cm	Weft type and sett, 1/ cm	Lock-out range (width)	Lock-out point
01, Plain, Bleached	1. Cotton, 12 2.Cotton covered spandex, 4	Cotton, 24	140%-180% (40%)	6.8N, 168%
02, Plain, Greige	1. Cotton, 8 2.Cotton covered Spandex, 5	Cotton, 25	145%-185% (40%)	6.7N, 167%
03, Plain, Bleached	1. Cotton, 11 2. Nylon covered spandex, 4	Cotton, 17	90% - 130% (40%)	8 N, 118 %
04, Plain, Greige	1. Cotton, 8 2. Cotton covered spandex, 5	Cotton, 16	110% -145% (35%)	12 N, 132%
05, Plain, Bleached warp & dyed weft	Cotton covered spandex, 11	Cotton, 24	110%-170% (60%)	10 N, 154%
06, Plain, Dyed warp & bleached weft	Nylon covered spandex, 17	Cotton, 12	58% - 98 % (40%)	12 N, 87%
07, Plain, Bleached	Cotton covered Spandex, 9	Cotton, 24 (12 double wefts)	40% - 68 % (28%)	12N, 59%
08, Plain Leno, Yarn dyed	Cotton, 20	Rayon multifilament, 13	90%-175 % (85%)	27N, 138%

Table 1 Cont.

Sample number, Weave, Finish	Warp type and sett, 1/cm	Weft type and sett, 1/ cm	Lock-out range (width)	Lock-out point
09, Warp knit, Yarn Dyed	1. Nylon multifilament type 1, 6 2. Rubber, 6 3. Nylon multifilament type 2, 15	No weft	150%-220% (70%)	27 N, 196%
10, Warp knit, Yarn Dyed	1. Nylon multifilament type 1, 6 2. Rubber , 6 3. Nylon multifilament type 2, 16	No weft	145%-215% (70%)	22N,186%

If we consider the lock-out behavior, the bandage 7 with the narrowest lock-out range of 28% elongation is the best, because it ensures a rapid change of elastic modulus from a lower constant value of 0.097 N/mm to 8.5 N/mm. This will ensure a high level of pressure change while standing and walking. However the tension achieved at lock-out is relatively low, and the lower amount of elongation before lock-out is also problematic. This will cause, in combination with relatively high elastic modulus before lock-out of 0.097 N/mm a rapid drop of pressure if limb dimensions tend to decrease after application of the bandage.

Bandages 8, 9, and 10 which are either warp knitted or leno woven display very wide lockout ranges. These will definitely cause problems in achieving a defined application tension. The application tension will depend on the strength of the person applying the bandage as the lock-out point is not well defined. However, the level of tension at lock-out is relatively high and hence supportive in achieving high supine pressures. These pressures are do not vary very much due the changes in the limb dimensions. Since these bandages are suitable to provide a sustainable high pressure even at varying limg dimensions.

The bandages 1, 2, 3 and 4 show the possibility of achieving relatively low lock-out ranges with different levels of total elongations as well as different elastic modulus before and after the lock-out region. Combination of stretch and non-stretch yarns in the warp of woven fabrics makes it possible to produce wide range of bandages with varying levels of total stretch and acceptably narrow lock-out ranges suitable for different patients who are in need of different levels of supine pressure.

4.2 Method to locate the lock-out point

All the bandages which had been tested do not display a clearly defined lock-out point but a lock-out range. We propose below a method to determine the lock-out point of such bandages with lock-out ranges of various widths.

Consider the load elongation curve of one of the tested bandages. The Fig. 2 shows the load elongation curve of the bandage no. 3, which is a woven bandage with Nylon covered spandex in warp and Cotton yarn as the weft.

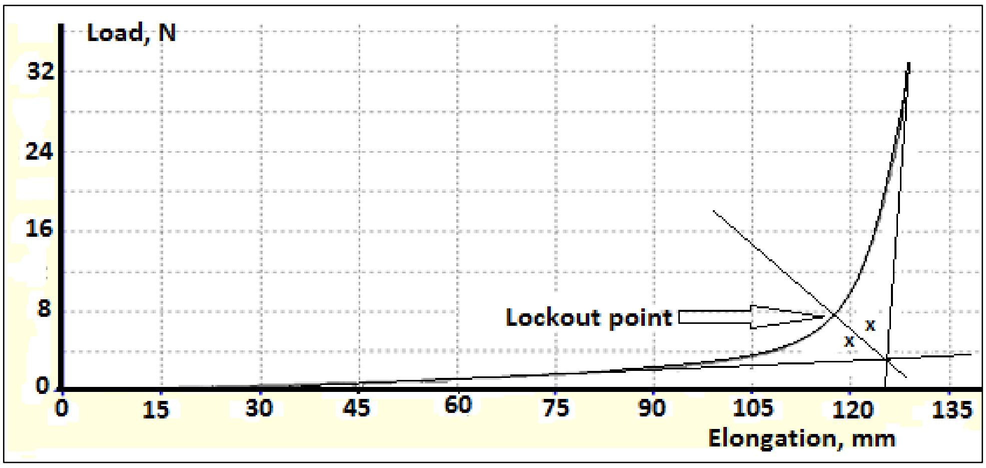


Figure 2 Construction method to locate lock-out point

Two tangents are drawn to the two straight portions of the curve before and after the lock-out region. The inclinations of these two tangents represent the elastic modulus before and after the lock-out point. The angle between these tangents is divided in to two equal parts by a third line (bisect). The intersection of bisect with the curve can be considered as the lock-out point. The lock-out elongation and tension of the above bandage is about 115% and 8 N respectively. This is the average tension which is assumed to be achieved during application of the bandage to the leg by a trained person. The tensions and elongations at so constructed lock-out points were determined for all the 10 bandages investigated under this project, which are given in the last column of the Table 1.

All warp-knitted bandages have high lock-out tensions and wide lock-out regions. Leno-woven bandage displays a high lock-out tension and a medium level lock-out elongation. Bandages made with one elastic warp produce medium level lock-out tensions and low-to medium lock-out extensions. Fabrics with two different warps give low to medium lock-out tensions and medium to high lock-out elongations.

4.3 Lock-out and bandage classification

According to Clark, 2003, short stretch bandages should lock-out at up to 70% elongation (ideally at 30% to 40% extension) and long-stretch bandages locking-up at over 140% elongation. Partsch, et Al., (2008) have defined bandages with 0-10% stretch at a load of 10N/cm as rigid bandages, those with 10-100% stretch as short stretch bandages and those with more than 100% stretch as long-stretch bandages. This classification is in agreement with the German Standard DIN 61632. Now let us see whether our findings support the above statements (Table 2).

Table 2 Lock-out point in relation to the class of the tested bandages

No.	Bandage Type	Elongation at 10N/cm load, %	Class of bandage	Lock-up point tension, elongation
1	Woven, one elastic & one non-stretch warp	195	Long-stretch	6.8N, 168%
2	Woven, one elastic & one non-stretch warp	205	Long-stretch	6.5N, 167%

Table 2 Cont.

No.	Bandage Type	Elongation at 10N/cm load, %	Class of bandage	Lock-up point tension, elongation
3	Woven, one elastic & one non-stretch warp	140	Long-stretch	8 N, 118 %
4	Woven, one elastic & one non-stretch warp	148	Long-stretch	12 N, 132%
5	Woven, one elastic warp	180	Long-stretch	10 N, 154%
6	Woven, one elastic warp	115	Long-stretch	12 N, 87%
7	Woven, one elastic warp	70	Short-stretch	12N, 59%
8	Leno woven, one non-stretch warp	170	Long-stretch	27N, 138%
9	Warp-knitted, two filament warps and one elastic warp	227	Long-stretch	27 N, 196%
10	Warp-knitted, two filament warps and one elastic warp	222	Long-stretch	22N,186%

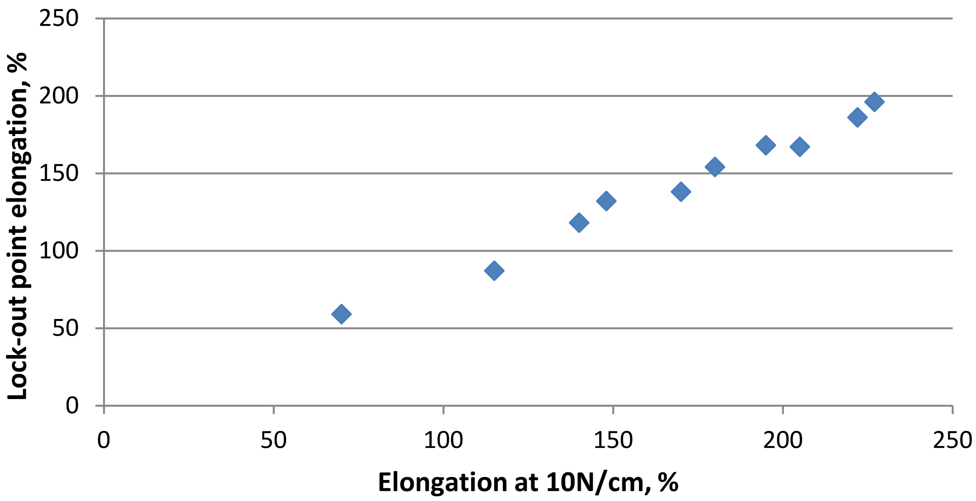


Figure 3 Lock-out point elongation Vs Elongation at 10 N/cm

According to the manufacturer, only one bandage of the tested bandages falls into the category of short-stretch, all other bandages are long-stretch. The only short stretch bandage has a lock-up extension of 59%, which agrees with the limit mentioned by Clark (2003). The long-stretch bandages have lock-up extensions from 87% to 196%. Hence the statement that long-stretch bandages lock-up at over 140% is not valid. The two warp knitted bandages(9 &10), two woven bandages with two types of warp (1 & 2) and one woven bandage with only an elastic warp (5) reach the limit of elongation of 140% at lock-out.

The Fig. 3 illustrates a clear correlation between total elongation at 10 N/cm and the lock-out extension. Therefore the bandages can be classified even according to the elongation at lock-out. However it is not logical to classify bandages based only on the elongation because it is not the elongation which we want to control but the tension.

Fig. 4 and Fig. 5 show that the tension at lock-out does not correlate with the elongation at 10 N/cm load or with lock-out point extension. However both these two figures show two clusters. One cluster comprises of leno-woven and warp-knitted fabrics, other of woven fabrics with elastic yarns of different percentages. The classification of bandages based on stretch can be applied to these two clusters separately.

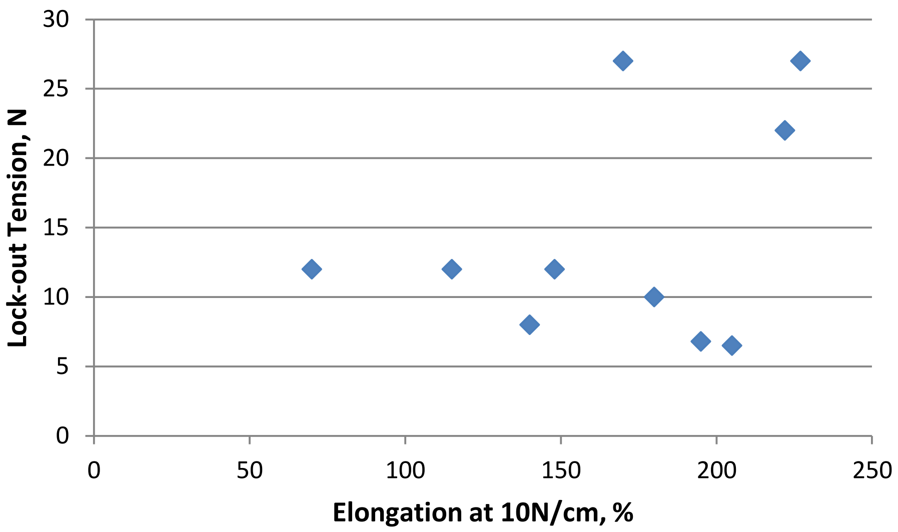


Figure 4 Lock-out point tension Vs elongation at 10 N/cm

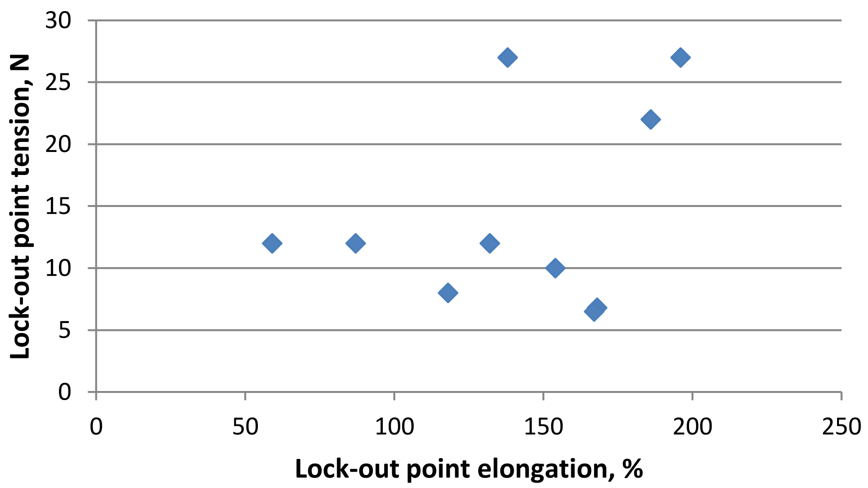


Figure 5 Lock-out point tension Vs lock-out point elongation

5 CONCLUSIONS

The term lock-out point is frequently found in publications on elastic bandages. However, none of the market available bandages exhibit a clear cut lock-out point but a range over which the elastic modulus rapidly changes from a very low value to a high value preventing/reducing further extension of the bandage with increasing load. This range varies from 28% elongation to 85% elongation for the bandages investigated(Table 1).

Using a method suggested in this publication we can determine a lock-out point and hence define a lock-out tension and a lock-out elongation for different bandages.

The results reveal that warp knitted structures with elastic and non-stretch yarns can produce bandages with very high lock-out tensions (22-27 N) and high lock-out elongations (186-196%). Even a closely woven plain leno fabric delivers a very high lock-out tension (27 N) but at a relatively low lock-out stretch (138%) (Table 1).

Woven bandages with only elastic yarns in the warp produce medium level lock-out tensions (10-12 N) at different lock-out elongations (59 -154%) (Table 1). No correlation can be found between the warp set or weft set and the lock-out tension/elongation. The structure of the covered spandex yarns used in the warp must be investigated to explain how these different lock-out points have been achieved.

Use of two different warp yarns (stretch and non-stretch) allows to achieve a range of different lock-out tensions of lower and medium level (6.7 -12). The lock-out elongations vary also in a wide range from 118% to 170%. A clear relationship between the amount of stretch yarns in the warp and the lock-out tension/elongation can't be identified. Here again the structure of the covered spandex yarns used in the warp must be investigated to explain how fabric construction affects the lock-out point.

Lock-out elongation correlates very well with the Elongation of bandages at a load of 10N/cm, but there is no correlation with lock-out tension(Figures 3,4 and 5) . The present method of classification of bandages according to extension does not provide a clear idea about application tension and the pressure generated under the bandages. The terms "rigid", "short-stretch" or "long-stretch" provide information on stretch-ability only, but not about the application tension. Hence there is a need to change the criteria used to classify bandages. The present classification can be used within the bandages having similar load/elongation behaviour.

The use of the terms "elastic" and "inelastic" to identify bandages of different stretch must avoided.

6 ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution made by Mr. D. K. Bogahapitiya, Technical Officer, Department of Textile and Apparel Technology of the Open University of Sri Lanka in carrying out experimental work of the project and the Faculty of Engineering Technology of the Open University of Sri Lanka for the provision of funds to carry out this project.

REFERENCES

1. Clark, M., 2003, Compression Bandages:principles and definitions, *Understanding Compression Therapy - EWMA Position Document,* Medical Education Partnership (2003), pp 5-7.
2. Marston, W. & Vowden, K., 2003. Compression therapy: a guide to safe practice*, Understanding Compression Therapy - EWMA position document,* Medical Education Partnership (2003), pp13.
3. Mayrovitz H.N., 2004. Compression therapy, A summary concepts and features [online] Available at http://bioscience research.net/LVP30/Compression Therapy_ConceptsAnd Features.pdf [Accessed on 29/12/2012].

4. Moffatt, C.J., 2005. Lymphoedema bandaging in practice. *European Wound Management Association (EWMA) focus document*, 2005, Medical Education Partnership (2005), pp1.
5. Mosti, G., Mattaliano, V. & Partch, H., 2008. Inelastic compression increase venous ejection fraction more than elastic bandages in patients with superficial venous reflux, *Phlebology* 2008(23), pp287-294.
6. Mosti, G., Mttaliano, V., Polignano, R. & Masina, M., 2009. Compression therapy in the treatment of leg ulcers. *ACTA VULNOL* (l 7)3, pp 2
7. Mosti, G., 2010. Short stretch bandages for leg ulcers, *Journal of wound technology* (8)4, pp 17.
8. Partch, H., 2005a. The Static Stiffness Index: A Simple Method to Assess the Elastic Property of Compression Material In Vivo. *Dermatologic Surgery* 31(6): pp 625-630.
9. Partsch, H., 2005b. The Use of Pressure Change on Standing as a Surrogate Measure of the Stiffness of a Compression Bandage. *European Journal of Vascular and Endovascular Surg*ery 30(3), pp 415-421.
10. Partsch, H., Steinlechner, E., Benigni, J. P., Cornu-Thenard, A., Gamble, J. Moffatt, C. & Rabe, E., 2008, Classification of compression bandages, Practical aspects, *Dermatologic Surgery* 34(5), pp 600-609.
11. Templeton, S., 2009. Presentation at education evening, South Australian Wound Management Association [online], available at www.wounds-uk.com/pdf/content_9070.pdf [accessed on 04/01/2013].