## The science and methods behind compression to enhance circulation –

## Static Compression

There are two main principles of compression therapy. The first one is to create an enclosed system in order to allow an evenly distributed internal pressure in the leg. This principle involves the application of Pascal's Law, which entails muscle movement generating a pressure wave that is distributed evenly in lower limbs during active and passive exercise. The compressive effect can reduce the diameter of veins by positioning valves and forcing the venous blood to return to the heart [1]. The second principle involves the application of Laplace's Law in order to create a varied interface pressure based on limb shape as well as the tension of the stocking or bandage applied [2]. As mentioned above, Lymphedema is a common condition where compression is being used in the management and the principle of action in compression stockings is by improving the calf muscle pumping on the veins as well as to help lymph propulsion by enhancing the extrinsic force such as contractions of the skeletal muscles adjacent to the lymphatic vessels [3] and another possible potential benefit of wearing compression stockings is to decrease the capillary filtration [4] thus, reducing the disease progression.

### 1. Static Compression Garments

Compression garments are individually designed and manufactured for a particular part of the body available as stockings, bandages, sleeves, body suits, etc. [5]. Medical Compression Bandages (MCBs) with gradual compression from distal to proximal regions and Graduated compression stockings (GCS) are usually utilized to conduct the compression therapy.

## 1.1. Medical Compression Bandages (MCBs)

The history of using compression bandages was reported from the era of ancient Egyptians, where they have used simple woven fabrics with coated adhesives and resins as dressings to help wound healing [6] The elastic compression bandages appeared very late in the development of compression bandages but long before the elastic stockings were introduced to the market. There are few classifications available for compression bandages, however a reliable international classification is not available [7]. Some of the available classifications are based on the type of the bandage (elastic or non-elastic), the interface pressure applied by the bandage, number of components available, and stiffness. The classification of bandages according to the level of pressure can provide an easy interpretation for the clinicians. In general, the interface pressure can be referred to as the pressure applied by the materials in contact; in this context, it is the pressure between the bandage and skin surface.

| | |
|---|---|
| <20 mmHg | Mild |
| 20–40 mmHg | Medium |
| 40–60 mmHg | Strong |
| >60 mmHg | Very strong |

Table 2: The compression pressure categorization [8]

Compression bandages of 35–45 mmHg pressure at the ankle were proven in several studies to be safe and effective [8, 9]. Possibility in achieving the required correct pressure profile is very much dependent on the skill level of the operator; therefore, patients by themselves cannot apply these and achieve the required pressure. To overcome this difficulty GCSs later were introduced to the market.

### 1.1.1. Graduated Compression Stockings (GCS)

The compression stockings work by the principle of exerting a higher pressure at the ankle, and gradually decreased pressure up towards the knee. Therefore, these are commonly referred to as GCS or medical compression stockings, and commonly comes in knee high, mid high and pantyhose with open and closed toe designs. GCS are commonly classified according to the interface pressure applied by the garment at the ankle level [10] The pressure exerted by the compression garment at the ankle is decisive for allocating it to one of the 4 compression classes according to RAL standards [11].

| Class | Compression | |
|---|---|---|
| Class I | 18–21 mmHg | Light compression |
| Class II | 23–32 mmHg | Medium compression |
| Class III | 34–46 mmHg | High compression |
| Class IV | >49 mmHg | Very high compression |

Table 3: RAL compression classes

### 1.1.2. Problems associated with Static Compression Garments

Static compression garments are being used as first line wear in the medical community as well as for the non-medical purposes which were mentioned above. While the advantages of these compression wear have been mentioned in the previous sections, they have their unique disadvantages as well.

a) Poor fitting stockings

Because most of these garments are nonadjustable, some people might find it being too tight or feel restricted in their movements or cause numbness to the body part [12] while conducting their daily activities.

b) Difficulty in donning and doffing

The elastic stockings have inherent difficulty in pulling them up through the ankle which requires an extra effort. Even though there are devices developed to assist in putting the stocking, considering most of those who wear these stockings are in the restricted category this is still a disadvantage.

c) Need expert skills for the application of bandages

MCBs need to be applied by an experienced health care worker in order to achieve the desired compression pressure and to prevent skin damages due to excessive pressure.

d) Cause skin irritation

Even if most compression gear are designed to absorb or drain sweat, there is still less air flow which predispose the skin for itchiness as well as irritative skin problems and dry skin which requires the consumer to use additional skin care products to prevent them.

e) Difficulty in reusing

Reusing the garments need frequent washing and air drying that requires an additional time to be spent on. With time, stockings tend to lose its elasticity which inevitably will reduce its original intended compression pressure.

f) Non-compliance

Because of the above disadvantages people tend to lose compliance for these products over time. The non-compliance rate for GCS, is reported to be 30 – 65% [13, 14] and the commonly stated reasons were pain, discomfort, perceived ineffectiveness, excessive heat, skin irritation and appearance.

Due to these disadvantages, people tend to move toward the newer devices such as Intermittent Pneumatic Compression (IPC) devices which do not have these drawbacks. Even though the initial cost of IPCs are high, their durability is far greater than the regular static compression wear.

## References


[1] J. Schuren and K. Mohr, "Pascal's law and the dynamics of compression therapy: a study on healthy volunteers.," *International angiology : a journal of the International Union of Angiology*, vol. 29(5), pp. 431-435, 2010.

[2] Y. Li and D. Dai, "Biomechanical engineering of compression stockings.," in *Biomechanical Engineering of Textiles*, Cambridge, Woodhead Publishing, 2006, pp. 332-344.

[3] R. Sugisawa, N. Unno, T. Saito, N. Yamamoto, K. Inuzuka, H. Tanaka, M. Sano, K. Katahashi, H. Uranaka, T. Marumo and H. Konno, "Effects of Compression Stockings on Elevation of Leg Lymph Pumping Pressure and Improvement of Quality of Life in Healthy Female Volunteers: A Randomized Controlled Trial," *Lymphatic Research and Biology*, vol. 14, no. 2, pp. 95-103, 2016.

[4] U. Wollina, M. B. Abdel-Naser and R. Mani, "A Review of the Microcirculation in Skin in Patients With Chronic Venous Insufficiency: The Problem and the Evidence Available for Therapeutic Options," *The International Journal of Lower Extremity Wounds*, vol. 5, no. 3, pp. 169-180, 2006.

[5] L. Wang, "Study of Properties of Medical Compression Fabrics," *Journal of Fiber Bioengineering and Informatics*, vol. 4, no. 1, pp. 15-22, 2011.

[6] S. Thomas, "Compression bandaging in the treatment of venous leg ulcers," in *World Wide*, 1997.

[7] M. Clark, "Compression bandages: principles and definitions," in *ewma position document.Understanding compression therapy*, London, Mep Ltd, 2003, pp. 5-7.

[8] H. Partsch, M. Clark, G. Mosti, E. Steinlechner, J. Schuren, M. Abel, J.-P. Benigni, P. Coleridge-Smith, A. Cornu-Thenard, M. Flour, J. Hutchinson, J. Gamble, K. Issberner, M. Juenger, C. Moffatt, H. Neumann, E. Rabe, J. F. Uhl and S. Zimmet, "Classification of Compression Bandages: Practical Aspects," *Dermatologic Surgery*, vol. 34, no. 5, pp. 600-609, 2008.

[9] E. J. C. Goldstein and M. S. Weingarten, "State-of-the-Art Treatment of Chronic Venous Disease," *Clinical Infectious Diseases*, vol. 32, no. 6, pp. 949-954, 2001.

[10] C. S. Lim and A. H. Davies, "Graduated compression stockings," *Canadian Medical Association Journal*, vol. 186, no. 10, pp. E391-E398, 2014.

[11] M. Todd, "Using compression hosiery to prevent rebound swelling," *British Journal of Community Nursing*, vol. 20, no. Sup10, pp. S20-S25, 2015.

[12] S. Tanaka, T. Midorikawa and H. Tokura, "Effects of pressure exerted on the skin by elastic cord on the core temperature, body weight loss and salivary secretion rate at 35°C," *European Journal of Applied Physiology*, vol. 96, no. 4, pp. 471-476, 2005.

[13] S. Raju, K. Hollis and P. Neglen, "Use of Compression Stockings in Chronic Venous Disease: Patient Compliance and Efficacy," *Annals of Vascular Surgery*, vol. 21, no. 6, pp. 790-795, 2007.

[14] S. Shingler, L. Robertson, S. Boghossian and M. Stewart, "Compression stockings for the initial treatment of varicose veins in patients without venous ulceration," *Cochrane Database of Systematic Reviews*, 2011.