The textile properties of Deep Vein Thrombosis (DVT) garments

A factor in patient compliance with Intermittent Pneumatic Compression (IPC) Systems

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Fabric technologies for use in the clinical environment are an important consideration, particularly where their use can help to prevent life threatening and avoidable patient injuries such as venous thromboembolism (VTE). This paper will examine some of the elements affecting the comfort of garments designed for Intermittent Pneumatic Compression (IPC). In particular it considers the garments marketed by Arjo (formerly ArjoHuntleigh) as part of the Flowtron Active Compression Systems (ACS), and how their design for comfort in use can help to contribute to wear compliance in the hospital setting.

Introduction

Venous Thromboembolism (VTE) is a leading cause of inpatient death[1]. It is a condition in which blood clots usually form in the deep veins of the leg or pelvis (known as a deep vein thrombosis or DVT), a portion of the clot can break off and travel via the systemic circulation to the lungs to cause a pulmonary embolism (PE). Together DVT and PE are known collectively as VTE. There are approximately 10 million cases of VTE reported worldwide each year[2] and these are associated with high economic and humanitarian cost[3]. As a result significant focus in recent years has been placed upon the prevention and reduction of VTE occurrence rates, with the introduction of quality improvement initiatives in many countries. Prevention strategies commonly adopted in clinical practice depend on the identification of those individuals at risk of VTE, along with timely intervention using appropriate methods of prophylaxis.

One such preventative strategy includes the use of intermittent pneumatic compression devices that consist of special garments worn on the leg and attached to a pneumatic pump that causes the garment to intermittently inflate and deflate. This action squeezes the calf muscle pump, causing blood to move in the deep veins of the legs to help prevent venous stasis and subsequent clot formation. The use of IPC as a prophylactic measure, requires the patient to wear the garments, continuously and for the recommended time periods, and this is vital to the success of IPC in reducing the risk of VTE formation.

Despite the value of IPC, compliance rates with the therapy have been reported as low as 19%.[4] This may be due to either nurses or patients removing and not reapplying the garments, for example when the patient has been to the bathroom, or for other procedures. Some patients may also find the garments uncomfortable and difficult to tolerate, particularly if they make the skin feel too hot, sweaty or itchy against the skin.

Increasing emphasis has therefore been placed on the comfort of VTE garments as an important aspect in improving wear time and overall concordance with IPC therapy. Better concordance is linked with reduced VTE event rates[5]. A randomised controlled trial evaluating patient compliance with IPC therapy demonstrated that a garment, which was more comfortable, was worn for longer periods[6].

Defining comfort

Comfort is a complex and interdependent combination of physical, psychological and sensorial perceptions that is highly dependent on the subjective interpretation of the individual. Since this subjective feeling differs from person to person, comfort is a very difficult phenomena to clearly define. A widely accepted definition for comfort is 'freedom from pain and from discomfort as a neutral state'[7].

Types of comfort

With most general items of clothing individuals are normally concerned with the visual (aesthetic appeal), thermal comfort or touch of the garment. In a hospital situation however, some aspects of aesthetic appeal are relatively insignificant, because the function and application of the garment is more important. The interaction between the body and the garment are the primary factors which may impact comfort in this respect.

The perception of comfort depends on many factors such as environmental parameters (air, radiant temperature, relative humidity and wind velocity), the metabolic heat and humidity produced by the human body and the thermal properties of the garment materials[8]. Wear or garment comfort is generally classified into two distinct categories – 'Thermal Comfort 'and 'Skin Sensational Comfort'[8].

Thermal comfort

The term Thermal comfort is generally used to describe an individual's state of mind in terms of whether they feel too hot or too cold[9]. It can be defined as the absence of any unpleasant sensations of being too cool or too warm, or of having too much perspiration on the skin[9]. In order to maintain good thermal comfort, it is important to balance the heat generated by the body through metabolism, with the heat lost or gained from the environment.

Skin sensational comfort

Skin sensational comfort is related to the mechanical contact of the fabric with the skin, its softness and pliability in movement and its lack of prickle, irritation and cling when damp[8]. Skin wetness affects perceived thermal comfort which differs in various parts of the body[10]. According to Fukazawa[10] the extremities are much more sensitive to thermal discomfort from wetness than the trunk of the body.

Maintaining heat balance: The body's natural response

The human body effectively maintains its own heat balance, through temperature regulatory mechanisms located in the hypothalamus within the brain. The hypothalamus maintains a core temperature of around 37°C (98.6°F), it monitors changes in blood temperature caused by thermal conditions within the body and the change of temperature across the skin[8, 11]. When the hypothalamus detects a body temperature less or higher than 37°C, it initiates physiological responses to increase or reduce body temperature.

Individuals adapt their behaviour to cope with their thermal environment, for example, adding or removing clothing, unconscious changes in posture, choice of heating, moving to or away from cooling/heat sources. The problems arise when this choice is removed, and people are no longer able to adapt[9]. In the hospital environment there is very little the patient can do to control or adapt to this situation and hence the need to focus on fabric properties is an essential element in helping to promote patient comfort.

How the body loses heat

Heat loss occurs primarily from the skin through several processes including, radiation, conduction, convection, and evaporation[8]. Radiation where heat is lost from the warmer core tissues within the body to the cooler atmosphere, is the most significant of these processes, accounting for approximately 60% of the total heat loss from the body[11]. The rate of heat loss by evaporation accounts for around 22%[11]. With increases in body temperature, the hypothalamus directs more blood flow to the skin and signals the body to start sweating. When sweating or perspiration occurs the evaporation of the sweat (i.e. liquid changes to moisture vapour) promotes heat loss and has a cooling effect on the body[11].

Improving patient comfort

One method of improving patient comfort is to focus on the garments ability to allow the passage of heat, air or moisture vapour away from the skin and through the fabric. Key success metrics in developing a garment that is comfortable for patients to wear are:

- Ensuring garment fabric is of a low thermal rating
- Using garment fabric that allows heat and moisture vapour through
- Ensuring fabric dries rapidly

Assessing the breathability and heat transfer capabilities of Flowtron DVT Garments

To demonstrate the Flowtron® DVT garment properties, they were tested at an independent UKAS accredited laboratory, to assess heat, air and water vapour characteristics following recognised test standards:

- Water Vapour Permeability WVP Index BS7209:1990 (1997)
- Ret Water Vapour Resistance EN31092
- Thermal Resistance (TOG) BS4745

Water vapour permeability

The transfer of water vapour away from the patients skin is a critical factor in patient comfort – this process refers to a fabrics breathability. Water Vapour Permeability (WVP) and Resistance Evaporation (Ret) are measures that are used to evaluate the breathability of a fabric.

Test method

A sweating guarded hot plate technique is used to mimic how fabric would perform in sweating skin conditions. It measures heat flow from the calibrated test plate (heated to a skin surface temperature of 35°C) through the material into the test environment (25°C, 65% Relative Humidity) and is determined for both simulated dry and wet skin conditions

Results

WVP measures the water vapour permeability of a fabric and therefore the degree of perspiration transported to the outside air. The higher the value, the more breathable the fabric. Flowtron DVT garments achieved a result of >85% when compared to a known fully breathable fabric (BS7209) (Figure 1)[12].

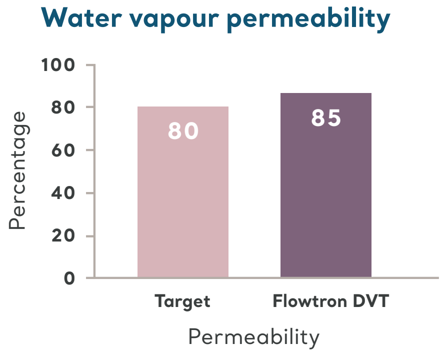

Figure 1: Flowtron DVT results of water vapour permeability testing

Fabric Breathability (Ret)

Ret measures the resistance to water vapour transmission through a barrier. Industry standards for high performance work wear state that a fabric which scores > 40 m^2 Pa/W (Pascal Watts) is non breathable, 20–40 m^2 Pa/W is semi-breathable and < 20 m^2 Pa/W is breathable. A good breathable work wear assemble with functional layers would be expected to have an Ret rating of <20 m^2 Pa/W (ISO 11092). The results for the material aspect of the Flowtron garments tested were in the region of 12.5 m^2 Pa/W[13]. (Figure 2). This indicates that the Flowtron fabric is effective in transferring water vapour through the fabric and has good breathability that it is unlikely to cause any additional discomfort when wearing due to overheating and/or sweating.

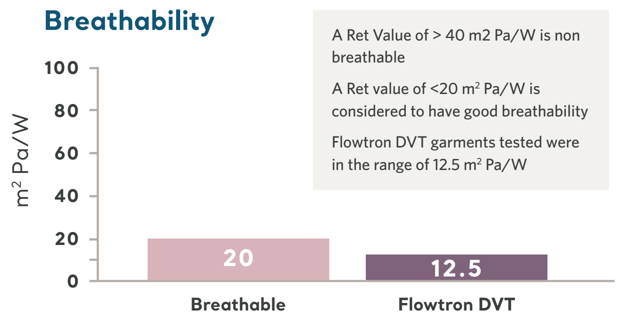

Figure 2: Flowtron DVT garment results of fabric breathability

Drying time

A fabric that remains wet and cold will draw heat from the body. The faster a material dries, the less likely the wearer is to experience heat loss and discomfort.

Test method

To determine the drying rate, of a saturated fabric, the dry weight of the sample specimen is first recorded. Fabric is saturated in water at 20°C, and the wet weight is determined. A set airflow is created over the specimen, and timing is started. The weight of the dish is automatically recorded in set intervals. When the weight is constant for successive readings or when the fabric returns to its original weight, the final weight is recorded.

Result

The Flowtron samples dried to within 99% of their original weight within a 6 hour period[14]. The garment fabrics also demonstrated a good wicking rate; after 5 minutes, moisture moved more than 50 mm[15], showing that perspiration can be conducted away from the middle of the garment to the edges quickly, helping to improve the speed of evaporation which helps to improve comfort.

Thermal Rating (TOG)

To minimise the risk of perspiration or increased heat production during wear time, VTE prevention garments should be non-thermal – this means that they do not generate additional heat.

Test method

The thermal rating of a textile can be measured using a single plate procedure which is performed to determine the thermal resistance of the fabric (Figure 3). The result uses the same units which are used to indicate the thermal rating of a duvet, known as the TOG rating.

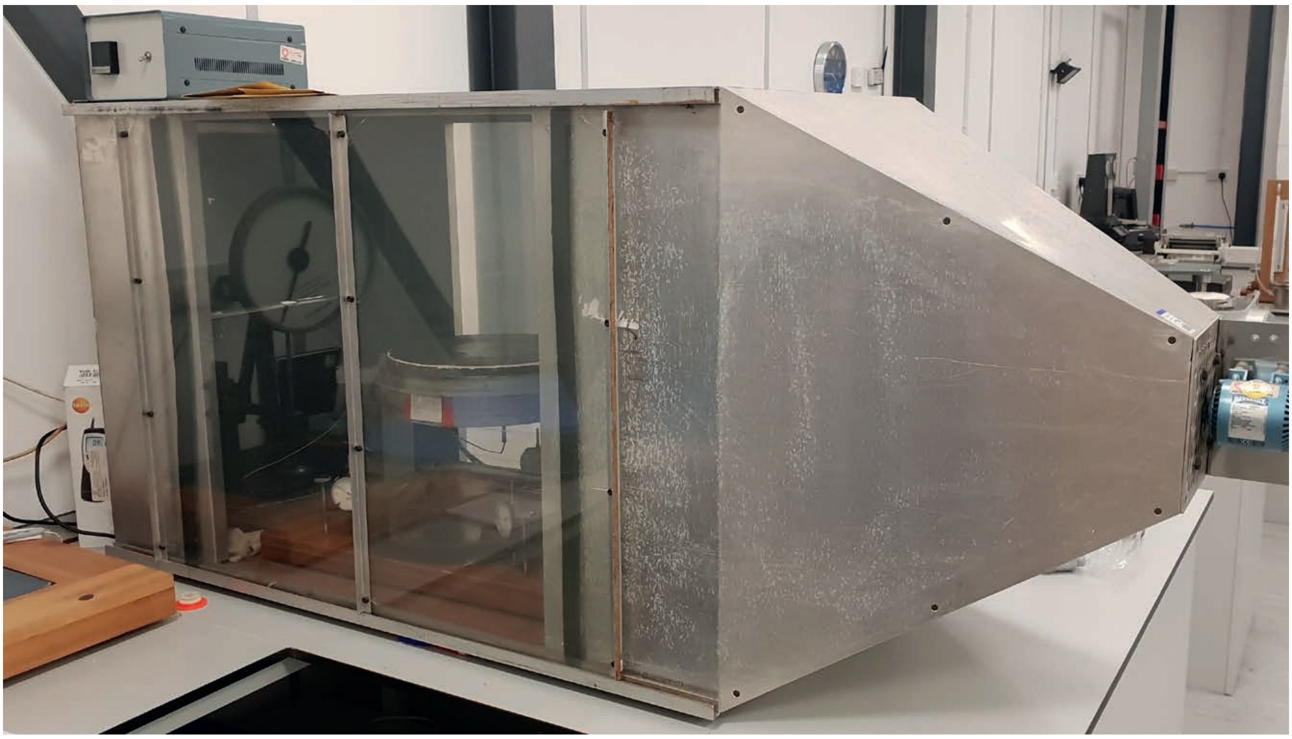

Figure 3: Lab equipment to assess the Thermal Rating (TOG) of a material

Result

The lower the TOG rating the less thermal in nature the material will be. A rating of less than 1 TOG is considered to have negligible thermal properties. Flowtron DVT garments recorded low thermal ratings of less than 1 TOG as a single layer material (Figure 4)[16]. This low thermal rating can be regarded as being non-thermal, preventing normal heat loss from the body surface and should remain comfortable during wear time.

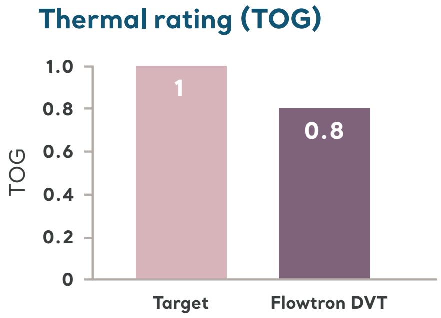

Figure 4: Flowtron DVT garments achieved a low thermal rating of less than 1 TOG as a single layer material

Conclusion

This paper has covered key factors which are important in the performance of the garment in promoting comfort and subsequent compliance with IPC therapy. The results of independent testing demonstrate that overall Flowtron DVT garments have been shown to be non-thermal in nature with excellent moisture management properties.

References

1. Cohen AT, Agnelli A, Anderson FA et al (2007) Venous Thromboembolism (VTE) in Europe: The number of VTE events and associated morbidity and mortality. Thromb Haemost 2007; 756-764
2. Jha AK, Larizgoitia I, Audera-Lopez C et al 2013. The global burden of unsafe medical care: analytic modelling of observational studies. BMJ Qual Saf 2013; 22:809-15
3. House of Commons: Health Committee (2005). The prevention of venous thromboembolism in hospitalised patients. HC99. London.
4. Cornwell, E.E., III, Chang, D., Velmahos, G., Jindal, A., Baker, D,. Phillips, J., Campbell, K. (2002) Compliance with sequential compression device prophylaxis in at risk trauma patients: A retrospective Analysis. American Surgeon, 68(5), 470-473
5. Nils Kucher, M.D., Sophia Koo, M.D., Rene Quiroz, M.D., M.P.H., Joshua M. Cooper, M.D., Marilyn D. Paterno, B.S., Boris Soukonnikov, M.S., and Samuel Z.Goldhaber, M.D., Electronic Alerts to Prevent Venous Thromboembolism among Hospitalized Patients N Engl J Med 2005; 352:969-977 March 10, 2005DOI:10.1056/NEJMoa041533
6. Pagella, P. Cipolle M. Sacco E. Matula P. Karoly E. Bokovoy J. (2007) A randomised trial to evaluate compliance in terms of patient comfort and satisfaction of two pneumatic compression devices. Orthop. Nurse, 2007, May-June; 26(3):168-74
7. Hatch, K.L. (1993) Textile Science, West Publishing Company, New York, NY, USA, 1993
8. Review of clothing Comfort. Textiletoday.com. Available at http://textiletoday.com.bd/review-of-clothing-thernal-comfort/. Last Accessed 22nd November 2018
9. Health & Safety Executive. Thermal Comfort. http://www.hse.gov.uk/temperature/thermal/index.htm. Last accessed November 2018
10. Fukazawa T; Havenith G, (2009). "Differences in comfort perception in relation to local and whole body skin wettedness". European Journal of Applied Physiology 106 (1): 15–24.
11. Diaz, M. Becker D.E. (2010) Thermoregulation: Physiological and Clinical Considerations during Sedation and General Anaesthesia. Anesth Prog 57:25-33
12. Independent Material Test Data on File: Test Report Number 60/01762; DVT 60L, Water Vapour Resistance (Ret), November 2017, page 4
13. Independent Material Test Data on File: Test Report Number 60/01762: DVT 60L, Water Vapour Permeability, November 2017, page 4
14. Independent Material Test Data on File: Test Report Number 60/00991: DVT 60L, Drying Test – Single Layer (No bladder) July 2017, page 6
15. Independent Material Test Data on File: Test Report Number 60/009991: DVT 60L, Liquid Wicking Rate (mean capillary rise, mm), Single Layer (no Bladder, July 2017, page 7
16. Independent Material Test Data on File: Test Report Numbers, 11/18925/PJH, December 2013, & 60/00991, July 2017: Thermal Resistance (single plate)

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