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The Effect of Fibre Compositions and Fabric Constructions on Elastic Properties of Compression Fabrics ⋆

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Abstract

This study aimed to investigate the impact of varying fibre compositions and fabric constructions on the elastic behaviour of compression fabrics. Knitted fabrics used as compression garments are subjected to deformation due to various loads used to extend the fabrics during wear. The loads to extend the fabrics are influenced by fabric constructions, strain levels and fabric directions. In this study, the strain of fabrics was measured using a commercial tensile testing machine (LR30K Lloyd) according to ASTM D496. Each sample was cycled five times between zero and the specified strain to replicate the repeated use of compression garments. In addition, the fabric was also heat-set and laundered to evaluate the impact of these treatments on the elastic behaviour of the fabric. The results indicated that different fabric constructions exhibited different elastic properties ($P < 0.05$), with 1×1 rib fabric demonstrating the highest load in the wale direction and terry fabric displaying the highest load in the course direction. Fibre composition in single jersey fabrics significantly affected ($P < 0.05$) their load requirements for extension, with 8% elastane displaying the highest resistance to stretching. Heat-setting positively affected the load capacity of the fabrics (24%-47%), enhancing the dimensional stability and strength. However, laundering after heat-setting decreased the load capacity (6%-32%), negatively affecting fabric deformation and shape retention. These findings aim to lay the groundwork for the importance of careful selection of fabric attributes and post-processing treatments for optimising the elastic properties of compression fabrics.

Keywords: compression fabric; fabric constructions; elastic behavior; tension decay; heat setting

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1 Introduction

Compression fabrics are used for medical, sports and body-shaping [1]. In the medical field, compression garments are used for scar management of burn patients, orthopaedic support and management of arthritis disease [2-5]. Most medical compression garments, such as stockings, gloves, sleeves, and bodysuits, are designed and manufactured for specific body regions with an engineered compression gradient. These materials are used over a specified time, depending on the need [5]. Due to their elastic nature, they generally provide a certain amount of pressure on the body parts for therapy treatment [6]. Some advantages of compression garments for sports applications in the market have been reported, for example, to improve blood flow, improve muscle oxygenation, reduce fatigue, improve recovery, reduce muscle oscillation, and reduce muscle injury [6-7]. In sports, it has become a popular tool for athletes to enhance performance in competition, reduce post-exercise trauma, reduce muscle soreness and reduce recovery time after exercise and training [8-9]. Additionally, Machado-Sousa et al. (2019) [10] reported that compression garments can even improve proprioception (body awareness) in athletes during exercise. These advantages were reported based on the fact that the compression garment is used as a principle for aerodynamics to reduce drag in high-speed sports and resist the impact force of muscle caused during running or jumping, thus decreasing unnecessary muscle vibration and applying pressure on specific muscle to increase blood flow [1, 11].

In developing compression garments, knitted construction with different stretch properties must be chosen, arranged and used for that particular body part. Fabric extensibility and ability to maintain stretching force influence the effectiveness of compression. The degree of pressure exerted by the garment depends on the garment design in terms of reduction factors and physical and mechanical characteristics, such as the fabrics' elastic behaviour and the material's thickness and density [12, 13]. Knitted construction also influences fabric density, even with the same parameters, such as knitting machine type, gauge diameter, and machine speed [13]. In line with this, Lia et al. (2015) [15] also reported that structural parameters of fabrics significantly affect compression properties. This emphasises the importance of considering fabric construction and fibre compositions when designing compression garments.

Compression garments are designed to be smaller than the actual body measurement by 10-50% measurements following fabric extensibility [4, 16]. Incorporating elastane yarns in knitted fabric improves stress-strain properties and fabric stretch and recovery [17, 18]. The addition of elastane yarns in the fabric enhances fit, stretchability and good shape retention of a garment throughout wear. It also provides better strength characteristics [19]. For medical compression garments, the constant stretching of compression fabric will alleviate the effectiveness of the garment, resulting in a loss of ability to exert appropriate pressure on the patient, thus reducing treatment effectiveness. Elastane yarn is usually processed with other ground yarn due to its higher extensibility and lower breaking strength. The percentage of additional elastane increases the weight of the fabric, and simultaneously, the course per inch and wales per inch becomes higher, thus increasing the stitch density and mass per unit area [20]. The presence of elastane in the knitted structure is expected to enhance stretch and recovery, flexibility and comfort in pressure garments [21].

However, since elastane fibres have a memory effect, they tend to revert to their original shape after being stretched and dimensionally unstable. Elastane yarn has a random molecular structure with many polymer bonds; thus, when working with elastane-containing fabrics, heat setting is often required during the finishing stage of grey fabric to give the fibres a rigid permanent structure