

A novel medical bandage with enhanced clothing comfort

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Abstract. Compression garments are special textile products which apply a pressure on needed body zones for supporting medical, sport or casual activities. Medical bandages are a group of these garments and they have a very common usage for compression effect on legs or arms. These bandages are generally produced by using synthetic raw materials such as polyamide or polyester fibres. Medical bandages are in contact with skin. Even if the synthetic fibres are used, they may cause both comfort and health problems like allergies. Nowadays in textile sector, the expectations of clients include using of natural fibres as far as possible in all garments. Natural fibres have good advantages such as breathability, softness, moisture management ability, non-allergenic and ecologic structure and these characteristics present optimum utilization conditions. In this study, tubular medical bandages were manufactured by using core spun yarns (sheath fibres are selected as tencel, bamboo and cotton, core material is elastane) and their pressure and comfort (air and water vapour permeability) characteristics were investigated. The results indicated that the bandages have good comfort abilities beside adequate pressure values for compression effect. These garments can constitute a new production field for medical bandages with their comfort properties in addition to pressure characteristics.

1. Introduction

Compression therapy is a form of healing that has been utilized since the time of Hippocrates (450-350 BCE) and has been applied as therapy for treating diseases such as vein disorders or oedemas. The working mechanism of compression therapy is an external application which applies compression to the skin in order to support the superficial venous system. This pressure forces the veins to narrow and there is a reduction in the volume of blood in the veins. As a result, the calf muscle pump can work better and the bloodstream is more easily able to move up toward the heart. Thus there is higher tissue oxygenation and better micro circulation [1].

Compression garments have a special function, which apply a certain pressure to the body mainly for medical, sports and body shaping [2]. Most medical compression garments are individually designed and manufactured for a particular part of body, such as stockings, gloves, sleeves, face masks and body suits [3]. Medical bandages are strip or tube form of materials used to protect, immobilize, compress or support needed body parts and they are most common groups of compression garments. They provide a compression pressure by wrapping body parts to support an injured limb, muscle or joint. There are different types of compression bandages such as long stretch, short stretch etc. Medical bandages are cheap and common equipment for compression therapy but there are some difficulties of using for patients. Even if new bandage systems have easy utilization process, the users need an expert help to adjust right pressure values for a successful treatment [4-7].



The success rate of compression treatment is directly related to right pressure profile and permanently using [8]. Compression garments are in contact to skin very closely with stretch ability to support blood flow and muscle systems. This situation causes discomfort for patients particularly in summer condition. Because of direct contact, there is only a few microclimate between skin and textile materials, so new structures with advanced comfort properties are needed to be used for compression garments.

A comfortable textile product generally should not create excessive change on body temperature; efficiently remove the moisture and water vapour to the atmosphere and not cause irritation or allergies on skin [9]. Natural fibers are favoured raw materials for comfortable textile products with specialties such as breathability, high moisture absorbance, softness, non-allergenic and ecological structure. They are especially used in products which are in contact with skin just like underwear. Instead of synthetic fibers, using natural fibers increase day by day with the help of innovative trends in textile industry. New developed regenerated fibers provide the inspiration for outstanding products with their comfort and mechanical characteristics.

There are few studies about comfort characteristics of compression garments. Some of them examined the fiber characteristics of compression stocking and they indicated that using some different natural fiber or different fiber blend improved the comfort characteristics of stockings. In the study of Oğlacioğlu et al. investigated the effect of regenerated cellulose fibers on thermal comfort properties of compression stockings. The results showed that some of different special yarns such as viscose, modal or tencel could be recommended for summer stockings due to low thermal resistance, high water vapour and air permeability characteristics [10]. Bera et al. studied that the effect of varying the nylon and cotton blend percentage on comfort properties of pressure garments. According to results, the fiber blend percentage did not have any influence on air permeability and thermal property. However water vapour permeability and wicking behaviour affected significantly. Increasing in nylon percentage increased both of them [11].

A different study is about the air permeability, water transmission rate and thermal behaviour of pressure garments in extended condition to simulate the conditions during wear. This study revealed that the comfort properties changed significantly when fabric was held in an extended state. In this state the fabrics became thinner and this made the structure more permeable to air as well as water vapour [12]. Also in some other studies, the comfort characteristics of some special pressure garments using for hypertrophic burn scars were investigated. The new developed fabrics compared each other fabrics for comfort characteristics. Yıldız studied to generate a novel technique to determine pressure garments for hypertrophic burn scars and comfort properties. The thermo-physiological test results of this new composite fabric revealed that it had extremely low water vapour permeability and high resistance to evaporative heat loss. The water absorption percentage and absorption capacity were too low when compared control fabric which is a sportwool and single-jersey knitted [13]. Anand et al. investigated that the determination of the suitability of four fabrics to be utilized for management of hypertrophic scarring. The dimensional, mechanical and thermo-physiological properties of fabrics procured from different sources were compared. All fabrics also showed excellent water vapour permeability and extremely low resistance to evaporative heat loss from the skin to the environment [14].

Medical bandages are usually produced using polyamide covered elastane yarn as inlay yarn and polyamide filament yarn as ground yarn. Polyamide fiber is a suitable raw material with better mechanical properties and stretch ability but there are some disadvantages of this fiber such as soft touch and allergenicity. This study aims to improve comfort characteristics of medical compression bandages in addition to ecological effect, soft handle, anti-allergic features. In the study, three elastane core yarns were produced using cotton, bamboo and tencel fibers as sheath and tubular medical bandages were knitted with these elastane core yarns as single jersey structure for wrist zone. Produced bandages were compared with commercially available polyamide tubular bandages in order to determine their sufficiency about pressure characteristics. Also the thermal resistance, water vapour and air permeability of these knitted fabrics were statistically analyzed.

2. Material and method

In this study, initially three types of core-spun yarns were produced with count of 370 dtex. In these yarns 200 dtex elastane was used as core and three different types of cellulosic fibers were used as sheath. These fiber types were: cotton, bamboo and tencel. Yarns were produced on ring spinning frame equipped with core yarn apparatus, in pilot spinning mill of Ege University Textile Engineering Department. Yarn parameters are given in Table 1.

Table 1. Yarn production parameters

Raw Materials	Linear Density	T/m	Core Elastane Yarn Count	Elastane Feeding Tension
Cotton				
Tencel	370 dtex	550	200 dtex	3.5
Bamboo				

Then, tubular single jersey fabrics were knitted on a industrial stockinette machine with the same machine settings by these yarns. Table 2 illustrates the specifications of these fabrics and testing standards.

Table 2. Testing standards and fabric properties

Fabric Properties	Testing method	Material			
		Cotton	Bamboo	Tencel	Polyamide
Stitch density (stitch/cm ²)	EN 1049-2	240	246	234	120
Thickness (mm)	EN ISO 5084	1.6	1.7	1.7	1.8
Mass per area (g/m ²)	EN 12127:1997	475	470	440	595

Pressure characteristics were also determined for wrist zone since it is the most important parameter for these types of bandages. Pressure tests were performed on a pressure measuring device improved for compression stockings [15]. At the last stage, air permeability, water vapour permeability and thermal resistance values of cotton, bamboo and tencel fabrics were measured according to the related standards on Textest FX3300, Permetest and Alambeta instruments, respectively. The results were comparatively evaluated by ANOVA tests using SPSS software in order to determine thermal comfort levels of samples (Table 3). Beside these evaluations, the properties of developed fabrics were also compared to a commercially available polyamide tubular bandage to have an idea about pressure and comfort sufficiency.

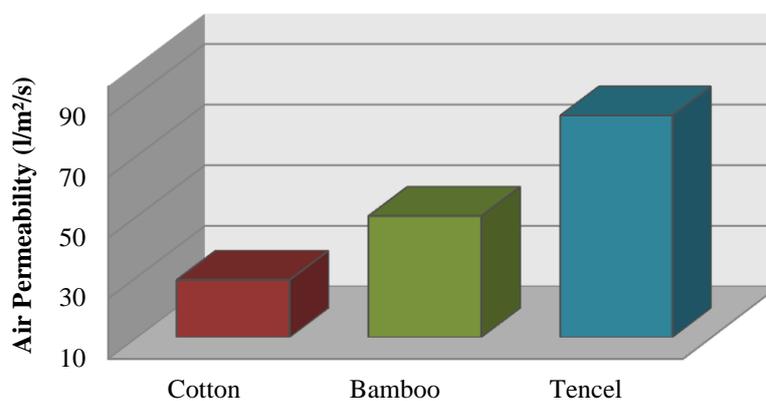
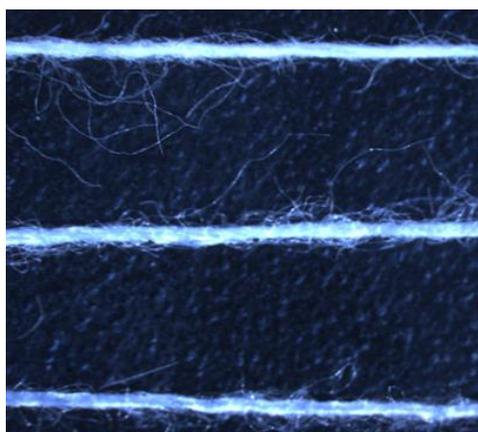
3. Results and discussion

The statistical results revealed that using different yarn type (cotton, bamboo and tencel) significantly changes thermal comfort parameters. On the other hand, pressure results proved that all fabrics were in the same pressure class (class II), since they were knitted on the same machine by the same production adjustments (as seen in Table 2) with the same yarn properties (Table 1). The pressure and thermal comfort values and statistical differences for each yarn type are given in Tables 3. In this table, the mean values are marked with the letters 'a', 'b' and 'c'. Any levels marked by the same letter showed that there is not any significant difference between the fabric types.

Table 3. Test results of measurements

Fabric Properties	Material			
	Cotton	Bamboo	Tencel	Polyamide
Pressure value (mmHg)	25.49 ^a	25.98 ^a	24.87 ^a	28.99
Air permeability (l/m ² /s)	28.93 ^a	50.01 ^b	83.19 ^c	55.88
Water vapour permeability (%)	36.48 ^a	36.76 ^a	38.28 ^b	34.23
Thermal resistance (W/m ² K)	0.0226 ^a	0.0310 ^b	0.0294 ^b	0.0256

Test results indicated that air permeability increase in cotton, bamboo and tencel fabrics, respectively, and tencel samples had the highest permeability within all samples (Figure 1). This result can be explained by lower hairiness and more compact structure of tencel yarn, as given in Figure 2, which provides higher fabric porosity and lower resistance to air penetration.

**Figure 1.** Air permeability results for different fiber types**Figure 2.** Microscopic yarn images

All samples have water vapour permeability values over 30%, which is accepted as limit for comfortable feeling. Whereas Tencel fabric achieves the highest water vapour permeability values as similar to air transfer property.

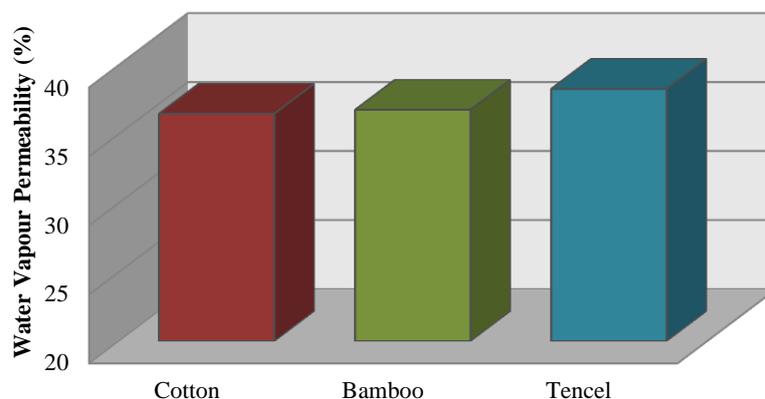


Figure 3. Water vapour permeability results for different fiber types

Cotton, bamboo and tencel are both cellulosic fibers, so it is expected them to have similar thermal conductivity values. However the entrapped air within the fabric structure significantly affects thermal properties [16]. The fabrics knitted by cotton yarns exhibit lower resistance to heat flow because of lower thickness and higher thermal conductivity. Since the thermal resistance property is proportional to the thickness of a layer and inversely proportional to its conductivity [17].

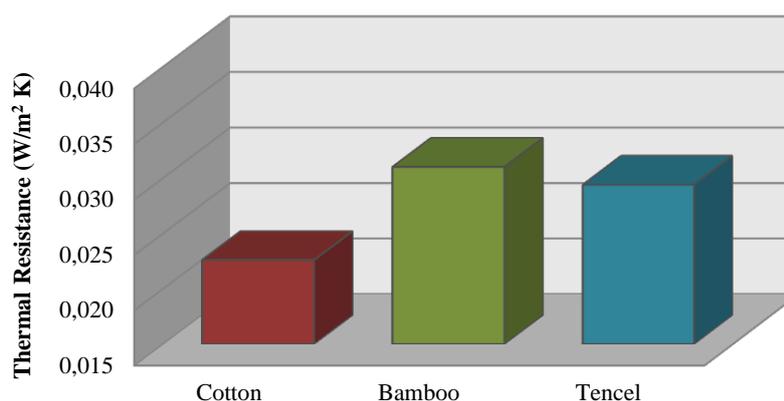


Figure 4. Thermal resistance results for different fiber types

4. Conclusion

Medical bandages are strip or tube form of materials used to protect, immobilize, compress or support needed body parts and they are most common members of compression garments. They are usually produced using polyamide covered elastane as inlay yarn and polyamide filament as ground yarn. In this study, elastane core yarn with cotton, bamboo and tencel fibers as sheath were produced and tubular medical bandage samples were knitted with these yarns.

The key factors of compression therapy are the right pressure profile and permanently usage. Compression garments apply higher pressure than a casual garment to the skin. Because of this feature, a small area for microclimate effect occurs between skin and fabric. This situation causes comfort problems for patient especially in warm conditions such as hot climate or during a physical activity. This research presents a new perspective of using natural core-spun yarns for medical bandage as a novel technique. In previous studies, some special or natural fibers were integrated to the compression garments as ground yarn, but together with polyamide covered elastane yarns. So these products showed a limited effect for comfort, because these fibers were not directly in contact with skin. In the scope of this study, the comfort properties of compression bandages are increased

significantly with using natural fibers as sheath of elastic core spun yarns. According to the comfort test results, the developed samples show comparable properties (Table 1) than classical synthetic bandages. It is stated that tencel fibers are the most ideal raw material in summer days with higher air and water vapour permeability.

With this study, adequate pressure values were reached for compression therapy. The pressure results indicated that all knitted samples are in the same pressure class with commercially available polyamide bandages. It is proved that the compression garments at same pressure levels can be manufactured with suitable machine adjustments and elastane yarn counts even if different fiber types are used.

For further researches various core yarn types can be investigated for different aims such as burn treatment, leg ulcers. Because this technique enables to produce special compression garments with using elastane core yarn covered by different special fibers as raw material.

5. References

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