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THE INFLUENCE OF POLYAMIDE FIBRES AND KNITTED FABRIC STRUCTURES ON THERMOPHYSIOLOGICAL PROPERTIES

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ABSTRACT

This study aims to analyse the influence of distinguished polyamide fibres knitted in different ways to improve the thermal physiological properties of fabrics used in clothing for bedridden patients. To this end, four distinct fibre compositions were, each one, knitted into four different structures, and this plan generated 16 samples. Structural characterization of the samples, permeability analyses, and Moisture Management tests were carried out. Was possible to conclude that some parameters such as filament dimension, fabric loop length, and how the yarns are knitted, have a direct influence on the thermal behaviour of knitted fabrics. The sample made of PA fibre 44/40 in a jersey fabric, presented the best results, due to its reduced thickness, superior loop length, and the use of a 40 multifilament.

KEYWORDS

Polyamide; Knitted fabric; Jersey; MMT; Thermophysiological properties; Thermal Comfort.

INTRODUCTION

Bedridden patients need special attention regarding skincare to avoid the development of bedsores. The Clinical Practice Guideline 2019 considers that excess moisture can lead to maceration and contribute to skin degradation, as well as the impact of oxygenation impairment and increased body temperature interferes with pressure injuries [1]. Therefore, regarding the technical quality of clothing for bedridden, thermoregulatory properties are an important requirement that provides a comfortable thermal and humid state, and therefore contributes to preventing the development of the aforementioned pressure sores. Given the above, many efforts have been made so that textile substrates can regulate the body microclimate, through phase change materials incorporated into fibres, that allow the storage, release, or absorption of energy in the form of heat. Some studies have shown the superior thermoregulation capacity of such fibres [2] and, on the other side [3], suggest the use of complementary fibres that have other properties, such as PA, regarding its intrinsic hydrophilic nature and low swelling characteristics. Therefore, this study aims to analyze the use of PA fibres with different dtex, and in different knitted fabric structures, to identify the parameters that contribute to better thermophysiological management.

MATERIALS AND METHODS

The knitted fabrics analyzed in this study were developed by Impetus company (Portugal). Four distinct fibre compositions were, each one, knitted into four different structures, and this plan generated 16 samples. Regarding the fibre compositions, a mixture of Ne40 cotton yarn with Viscose outlast® is constant for all samples on the outer side of the knitted fabrics. On the other hand, what differs is the side in contact with the skin, composed of PA and elastane fibres with different titles, see Table 1.

Table 1. Knitted fabric codes and their fibres composition.

	INNER	OUTER
A	EA 22 dtex + PA 44 dtex /34	Ne40 CO/CV outlast®
B	EA 17 dtex + PA 44 dtex/40	
C	EA 17 dtex + PA 22 dtex/9	
D	EA 17 dtex + PA 44 dtex/34	

Regarding the knitted structures, Figure 1 shows the point paper plain textile for each one. The yellow colour indicates a normal point, the white a charged point, and the black, the floating-point.

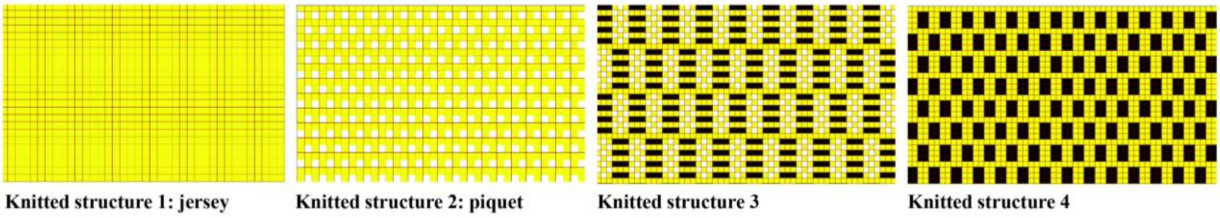

Figure 1. Point paper plan textile of the 4 distinct knitted structures.

Structural analyses

The samples were characterized in terms of thickness using the Mitutoyo device (No. 2046F), mm scale. 10 measurements were performed, and then an average was obtained. For the mass per unit area (g/m^2), the NP EN 12127:199 standard was followed.

To determine the length of yarn in the loop, (ℓμ), a given number of columns was selected and it was delimited with two lateral cuts. Then, ten rows of the knitted fabric were unravelled, and the length of the unravelled yarns was measured. The average value of the ten readings was identified and the length of the loop yarn, ℓμ, was calculated by dividing the average length of the measured yarns (ℓ) by the number of selected structural columns (N).

Permeability analyses

For the air permeability measurement, according to EN ISO 9237, the FX 3300 device was used, 10 measurements were performed on 10 different specimens, whose area is 20 cm^2, at a pressure of 100 Pa. The water vapour permeability tests were carried out by the BS 7209: 1990 standard, where 3 specimens of each sample were subjected to the test lasting 24 hours.

Moisture Management analysis

Assays were performed according to AATCC Method 195. For this purpose, 3 replicates per sample, 10 cm in diameter, were positioned between the Moisture Management testes (MMT), an instrument that consists of upper and lower concentric moisture sensors, between which the fabric is being tested is placed. A sweat-mimicking solution is poured onto the upper side of the sample (skin side) and then the test solution will be transferred to the material in three directions: Spreading outward on the upper surface of the fabric; Transferring through the fabric from the upper surface to the bottom surface; Spreading outward on the bottom surface of the fabric.

RESULTS AND DISCUSSION

As observed in Figure 2 a), for all fibre combinations (A-D), the knitted fabric thickness increases gradually as their structure changes from 1 to 4, indicating that the thinner structures are the jersey knits (1). Regarding the mass per unit area, the sample composed of PA 44/40 in the pique structure (B, 2), presented the lowest g/m^2 ratio, Figure 2 b). In addition, the loop length is another structural parameter that contributes to the thermal behaviour of the knits. Table 2 shows that structures 2 and 4 have 2 different fabric loop lengths, and structure 3 has 3 loop lengths.

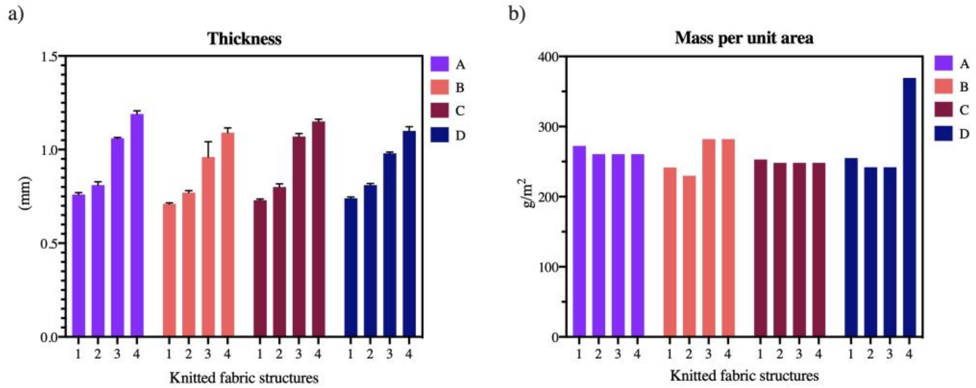

Figure 2. a) Knitted fabrics' thickness, where the x-axis indicates the knitted structures and the colours indicate the composition of the fibres; b) mass per unit area of the samples.

Table 2. A-B are the knitted fabric compositions, and the numbers 1-4 are the knitted fabric structures.

FABRIC LOOP LENGTH (CM)				
	1	**2**	**3**	**4**
A	0.31	0.19 / 0.31	0.16 / 0.22 / 0.32	0.20 / 0.32
B	0.31	0.19 / 0.31	0.16 / 0.22 / 0.32	0.19 / 0.31
C	0.31	0.19 / 0.30	0.16 / 0.23 / 0.31	0.19 / 0.31
D	0.32	0.20 / 0.31	0.16 / 0.22 / 0.31	0.19 / 0.32

In agreement with what was previously described, it is remarkable through Figure 3 a), that knitted structures 2 and 1 contributed, in all fibre combinations, to improve the air permeability of the samples. This biophysical property of textile substrates is directly influenced by the dimension and distribution of pores in textile geometry. Therefore, by increasing the loop length, the porosity of the substrates will be increased, resulting in better air permeability. Since structures 1 e 2 is a jersey and pique knitted fabric, they have the longest loop lengths, and their air permeability tends to be superior [4]. These results can also be corroborated by the inferior thickness of such samples, which facilitates the passage of air. Another important factor is the Filament Fineness (dtex). The sample that has the lowest dtex also has the highest air permeability (sample C).

In addition to the above, it should be noted that the sample composed of PA 44/40 obtained the best response regarding the water vapour permeability property, Figure 3 b). This suggests that, in addition to the knitted fabric structure, a filament with a higher shape factor has a large perimeter with the same cross-sectional area, which increases the capillary pressure resulting in fast capillary flow within the fabric [5].

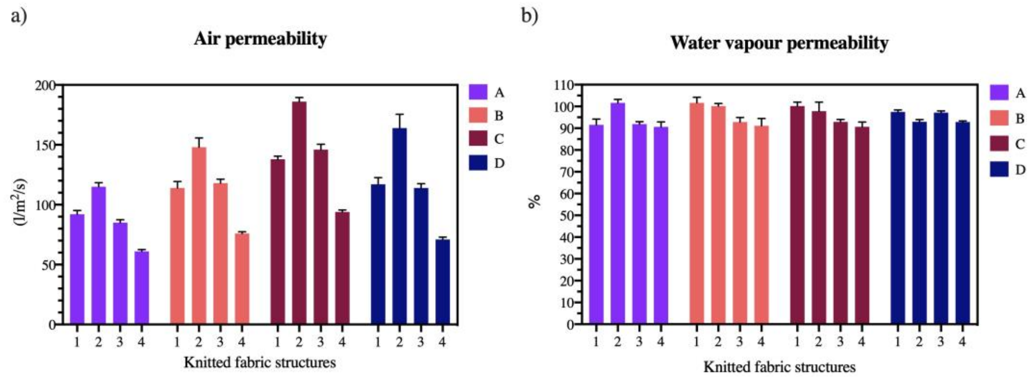

Figure 3. a) Knitted fabrics' Air Permeability; b) Water vapour permeability of the samples.

As seen in Figure 4 a), structures 1 and 2 also contributed to a higher absorption rate, which can be explained by their smaller thickness, leading to quick moisture diffuses. Except for sample D, which showed a high standard deviation. Beyond, in agreement with the water vapour permeability results, the samples composed with a large specific surface area (A and B), showed a higher absorption rate and one-way transport capability, Figure 4 b).

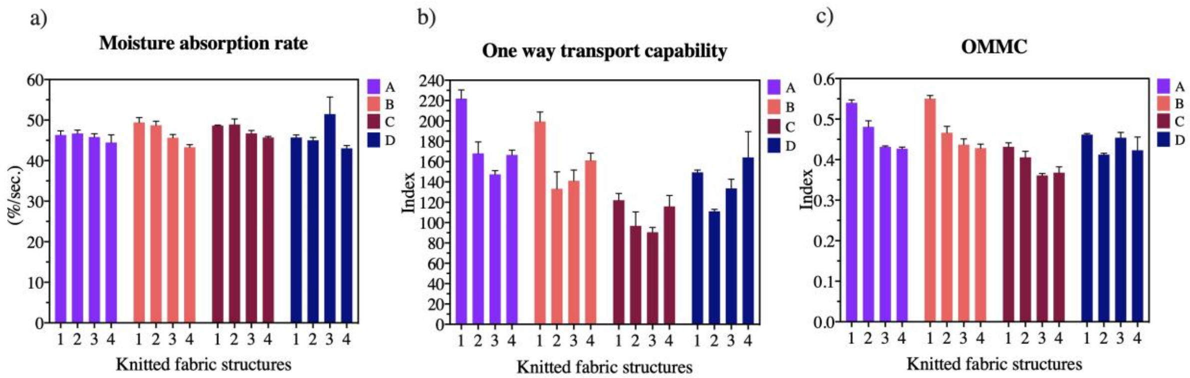

Figure 4. a) Moisture absorption rate; b) One-way transport capability; c) OMMC, of the knitted fabrics.

Given the above, when such parameters are analyzed concurrently, the result indicates that sample B structure 2, that is, PA fibre 44/40 in a jersey structure, presented a better OMMC index, therefore, the best performance for the moisture management, see Figure 4 c).

CONCLUSION

This study analyzed how some parameters such as filament dimension, fabric loop length, and how the yarns are knitted, have a direct influence on the thermal behaviour of knitted fabrics. And, in this sense, it was possible to conclude that knit with reduced thickness, superior loop length, and the use of multifilament, contribute to better absorption and desorption of moisture in the outer layer, as well as diffusion of moisture through the pores and forced convection by the movement.

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