

Effect of knit structure on the moisture management of sports jersey fabrics

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ABSTRACT

The knit structure is the primary factor that influences the moisture management properties and liquid transport in sportswear fabrics. Four polyester microfibre sports jersey fabrics were characterised by their fibre composition using Fourier Transform Infrared Spectroscopy (FTIR), and their moisture management performance was assessed in terms of absorption rate, wetting time, spreading speed, maximum wetted radius, Accumulative One-way Transport Index (AOTI), and Overall Moisture Management Capability (OMMC). Results showed that different knit structures had a noticeable impact on overall moisture management, with polar eyelet fabric showing faster surface wetting, a larger wetted radius on the bottom surface, and higher spreading speeds on the top and bottom surfaces of the fabrics. Statistical analysis using one-way ANOVA and Tukey's HSD showed significant differences between the fabrics in terms of spreading speed, wetted radius, AOTI, and OMMC. Overall, the polar eyelet fabric offered rapid surface wetting and spreading, while the interlock fabric performed better in one-way moisture transfer.

Keywords: *Comfort, Moisture management, Knit structure, Sports jersey, Polyester microfibre*

1. INTRODUCTION

Thermal comfort is one of the important factors to be considered in choosing sportswear for high-intensity exercise, especially in hot and humid weather where the excessive heat and sweat accumulation can affect the performance of the athletes. During exercise, body heat is dissipated mostly through sweating, thus making the moisture transfer behaviour of textile materials one of the important reasons for keeping the wearer feeling comfortable during exercise [1]. Polyester microfibre fabrics are therefore widely used in sportswear applications due to their lightweight features, low moisture retention, and high drying rate properties [2, 3].

However, the moisture management performance of the polyester microfibre fabrics is strongly influenced by their structural characteristics and knit constructions. Variations in fabric thickness, surface texture and surface morphology of the fabrics can lead to significant differences in liquid moisture transport and evaporation behaviour [4, 5]. Some of the fabrics may have a more porous structure which can help in faster moisture absorption and quick drying [6, 7], while the others might have spacer structures that allow

better air circulation and thus facilitate the moisture away from the skin [8, 9].

The rate at which the fabric absorbs moisture and retains thermal comfort while exercising can be affected by these structural factors and the knit construction of the sportswear, which can have a significant impact on its performance due to the absorbency of the fabric and the way sweat is transferred across the fabric surfaces. Features of the knitted structure, such as mesh configuration or the incorporation of the spacer yarns, create variations in pore size and inter-yarn spacing that could influence the moisture absorption and lateral spreading within the fabric. Previous studies have reported the use of twisted yarns which showed some improvement in moisture diffusion, while the hydrophobic profiled polyester fibres performed better under saturated conditions [10].

The mesh fabrics with increased loop lengths showed reduced moisture management, despite increased thermal resistance [11]. Meanwhile, 3D spacer fabrics with a hexagonal net structure showed improved vertical wicking and directional moisture transfer, which can be further

enhanced by the application of a thermal gradient between the fabric layers, while the fabric thickness has a minimal effect [12, 13]. Previous research has been done on the moisture management properties of multi-layer fabrics, which can be used to enhance moisture-wicking characteristics and provide better control over moisture retention and also moisture distribution [14–16]. The bi-layer knitted fabric with a polyester inner layer and a bamboo outer layer of the fabric showed superior thermal comfort properties, which increased air and water vapour permeability and drying performance, hence making it suitable for sportswear application [14]. Meanwhile, a study on double-layer cotton/polypropylene yarns provided good longitudinal wicking and general moisture management capabilities. Consequently, their linear density is also significant in this condition [15]. Double-face knitted fabrics with microfibre polyester in the top layer of the fabric and bamboo in the bottom layer of the fabric, on the other hand, performed better in terms of moisture control and were quite appropriate for sportswear because of their capacity to rapidly release perspiration and keep the wearer dry [16].

Although the sportswear fabrics are continuously being researched, the mechanism of how various knit structures of polyester microfibre jerseys perform under controlled testing conditions is not well understood, and the moisture management behaviour of various knit structures of fabrics made from microfibre is rarely reported. To address the knowledge gap, four types of knit structures that are commonly used in sports jerseys, namely, mini mesh (MM), polar eyelet (PE), eyelet (EY), and interlock (IT) fabrics, were assessed to clarify the effect of the knit structure on the moisture management behaviour and functional performance of the sportswear.

2. MATERIALS AND METHODS

An experimental approach was employed to investigate the impact of knit structure on the moisture management behaviour of polyester microfibre sports jersey fabrics. Four of the most widely used knitted sports jersey fabrics were selected for study: MM, PE, EY, and IT. The fabrics were analysed for fibre type and basic physical characteristics, material characterisation was performed using Fourier Transform Infrared Spectroscopy (FTIR), and structural features were analysed using optical microscopy and Scanning Electron Microscopy (SEM) instruments.

Standard testing procedures were used to evaluate the moisture management performance, including the parameters of wetting time, absorption rate, spreading speed, maximum wetted radius, the Accumulative One-way Transport Index (AOTI), and the Overall Moisture Management Capability (OMMC), and then statistical analysis was performed using one-way analysis of variance (ANOVA) and followed by Tukey's HSD to determine whether observed differences in moisture management behaviour between the fabrics were statistically significant.

2.1. Materials

Four polyester microfibre fabrics, widely used in sportswear jerseys, namely MM, PE, EY, and IT, were chosen for this study and purchased from a local sportswear distributor. Prior to testing, all fabric samples were conditioned for 24 hours under standard atmospheric conditions of $20 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ relative humidity, in accordance with the ASTM D177, to ensure consistency and reliability of the test results [17].

2.2. Physical and Structural Characterisation

Physical and structural properties of the fabrics were assessed based on the ASTM standard test methods for fabric thickness, mass per unit area (g/m^2), and stitch density of the fabrics. The thickness of the fabrics was measured according to the ASTM D1777 [18], while mass per unit area was determined in accordance with ASTM D3776 [19]. Then, the stitch density of the fabrics, expressed as wales per inch (WPI) and courses per inch (CPI), was measured as ASTM D1577 [20].

2.3. Fibre Identification by Fourier Transform Infrared Spectroscopy (FTIR)

To identify the chemical composition and functional groups within the four sports jersey fabrics, a fibre identification test was performed using Fourier Transform Infrared Spectroscopy (FTIR), which is a technique that uses infrared radiation to scan the samples from 4000 to 650 cm^{-1} to show the main absorption bands of the functional groups O–H, C–H, C=O, and N–H, in order to confirm the presence of the polyester backbone and identify any possible surface treatments or finishing agents.

2.4. Microscopic and SEM Analysis of Fabric Structure

Four polyester microfibre fabrics were analysed in terms of their surface characteristics, with the analysis of fabric structure carried out using optical microscopy and scanning electron microscopy (SEM). Optical microscopy was carried out with the fabrics mounted on a glass slide, using reflected light at $30\times$ magnification to analyse the surface texture and the knitted fabric. SEM was conducted on the face and the back of the fabrics; images were taken at $120\times$ magnification, with the fabrics attached to aluminum stubs using carbon tape, coated with a thin layer of gold and analysed at the specified level of magnification. These techniques allowed for more effective comparison of the fabrics and linking their structural features with moisture management behaviour.

2.5. Moisture Management Test

The moisture management properties of the fabrics were evaluated using a Moisture Management Tester (MMT, SDL Atlas) according to the standard test method of the American Association of Textile Chemists and Colorists

(AATCC), Test Method 195-2011 [21]. The fabric specimens are cut into 80 × 80 mm squares for testing. The MMT test measures the liquid transfer performance of the fabric, with the results of six performance parameters: wetting time, absorption rate, maximum wetted radius, spreading speed, accumulative one-way transport index (AOTI), and overall moisture management capability (OMMC).

2.6. Statistical Analysis

The experimental data obtained from the moisture management tests were analysed using IBM SPSS Statistics version 29.0 to determine if there were any significant differences in the means between the different fabric types using one-way analysis of variance (ANOVA) with Tukey HSD post-hoc tests to compare all pairwise differences at a 95% confidence level.

3. RESULTS AND DISCUSSION

3.1. Physical and Structural Properties

The physical properties of the fabric, including fabric thickness, mass per unit area, and stitch density (wales per inch and courses per inch), are given in Table 1. The thickness of the MM fabric is 0.58 mm, the mass per unit area of the MM fabric is 165.8 g/m², the wales per inch of the MM fabric is 37 wpi, and the courses per inch of the MM fabric is 55 cpi. The thickness of the PE fabric is 0.51 mm, the mass per unit area of the PE fabric is 189.0 g/m², the wales per inch of the PE fabric is 42 wpi, and the courses per inch of the PE fabric is 55 cpi. The thickness of the EY fabric is 0.69 mm, the mass per unit area of the EY fabric is 192.9 g/m², the wales per inch of the EY fabric is 36 wpi, and the courses per inch of the EY fabric is 30 cpi. The thickness of the IT fabric is 0.52 mm, the mass per unit area of the IT fabric is 188.1 g/m², the wales per inch of the IT fabric is 53 wpi, and the courses per inch of the IT fabric is 58 cpi.

Thicker fabrics, such as EY fabrics, have a greater capacity to retain moisture for a longer period of time because of the greater material thickness, but it is also possible that such fabrics may not be able to absorb moisture as quickly as thinner fabrics, such as PE fabric, which allows moisture to penetrate the fabric more quickly. The mass of the fabrics per unit area also helps in moisture retention, where the PE fabric, having a greater mass of 189.0 g/m², can retain more moisture than the lighter MM fabric, having a mass of 165.8 g/m², which can allow moisture evaporation more quickly. The number of wales and courses per inch helps in determining the density of the fabric and fabric tightness, where the IT fabric, having the greatest stitch density, may

be able to prevent moisture transfer but can transfer moisture in a particular direction, retaining moisture within the fabric and transferring it to the outer layer, whereas the EY fabric, having a lower density, allows moisture transfer and quicker drying due to its more open structure. As a result, variations in these physical properties influence the way moisture is managed by each fabric, influencing comfort and performance in sportswear.

3.2. Fourier Transform Infrared Spectroscopy (FTIR) Analysis

The results of FTIR spectra are shown in Figure 1. The combined spectra for all fabrics confirmed their similar chemical composition and verified the structure of the polyester backbone, confirming its molecular structure and its functional group relationship. FTIR tests confirmed that all four fabrics were composed of polyethylene terephthalate (PET). The FTIR spectra determined that the stretching absorption for the carbonyl group (C=O) of all four fabrics occurred at ~1717–1720 cm⁻¹, which indicated the presence of ester linkages in the polymer backbone. There were strong absorption bands for C–O stretching occurring at 1240–1246 cm⁻¹ and 1099–1102 cm⁻¹ for all fabrics, also indicating the presence of ester linkages. There are strong absorption bands for aromatic C–H stretching occurring within 3000–3100 cm⁻¹ and bending occurring within 724–726 cm⁻¹, confirming that benzene rings were present in their backbones for all four fabrics. The aliphatic C–H stretching vibrations also occurred within 2850–2960 cm⁻¹, confirming that they contained polyester side chains.

Although there were minor variations in peak intensity among the four knit structures, the spectra were largely similar, indicating comparable chemical composition. Despite the similarity in FTIR peaks observed across the fabrics, slight differences in the spectra may be attributed to variations in the fabric structure and surface characteristics, rather than the application of any coating. No coatings were applied to the fabrics in this study, and the FTIR results confirm that all four fabrics are made from the same polyester polymer.

Figure 2 shows the molecular structure of polyester (polyethylene terephthalate, PET), highlighting the ester functional groups (–COO–) and aromatic rings that correspond to the characteristic absorption peaks observed in the FTIR spectra. As confirmed by FTIR analysis, all four fabrics in this study are composed of the same polyester polymer. Therefore, the molecular structure and functional groups are identical for all samples, and variations in

Table 1. Physical properties of sports jersey fabrics

Fabric structure	Thickness (mm)	Mass per unit area (g/m ²)	Wales per inch (wpi)	Courses per inch (cpi)
Single jersey MM	0.58	165.8	37	55
Single jersey PE	0.51	189.0	42	55
Single jersey EY	0.69	192.9	36	30
IT	0.52	188.1	53	58

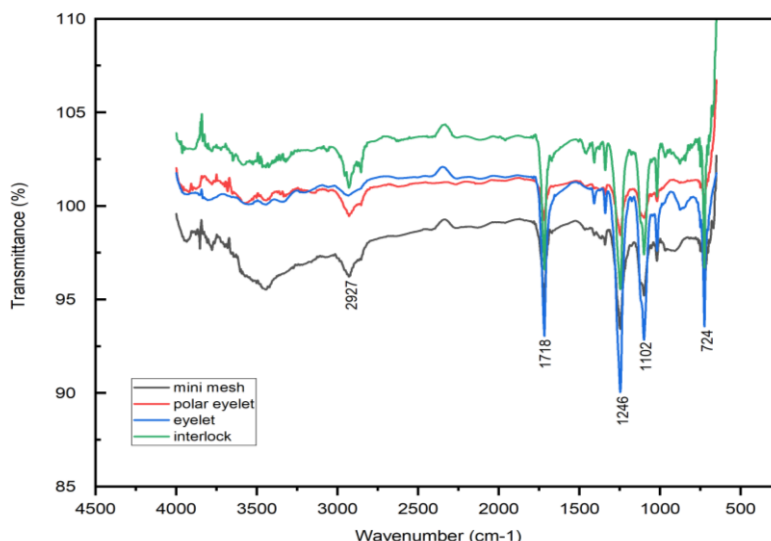


Figure 1. FTIR results of MM, PE, EY, and IT fabrics

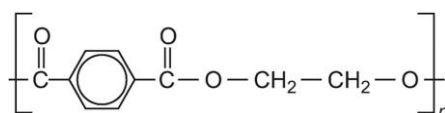


Figure 2. Molecular structure of polyester (PET), showing the repeating units of ethylene glycol ($-\text{CH}_2-\text{CH}_2-$) and terephthalic acid ($-\text{CO}-\text{C}_6\text{H}_4-\text{CO}-$) with ester functional groups ($-\text{COO}-$) [13]

moisture management performance are due to differences in fabric structure rather than polymer chemistry. Studies have shown that liquid transport and moisture management in textiles are mainly influenced by fabric structure, porosity, and capillary forces rather than by chemistry alone, especially among hydrophobic synthetic fibres such as polyester [22–24].

3.3. Microscopic and SEM Evaluation of Fabric Structures

Microscopic analysis, as shown in Figures 3 to 6, showed distinct differences in fabric construction among the four polyester microfibre sports jerseys. MM fabric showed

small, evenly spaced openings with moderately packed yarns, balancing airflow and stability. PE fabric featured large, regularly arranged apertures, maximising ventilation and enabling rapid moisture evaporation, along with a smoother surface due to its uniform and flat structure, which produces a more even surface and fewer interruptions in the fibre surface. The EY fabric had smaller and closely spaced openings, thus providing moderate breathability.

The surface of the IT fabric was smooth and non-porous, which restricted the airflow and potentially enhanced the directional transfer of moisture. These observations were supported by the SEM imaging, as seen in Figures 7 to 10,

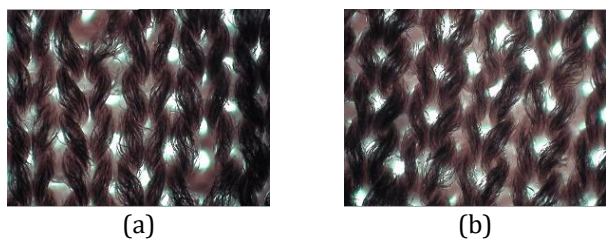


Figure 3. Microscopic views of MM fabric (a) front and (b) back



Figure 4. Microscopic views of EY fabric (a) front and (b) back

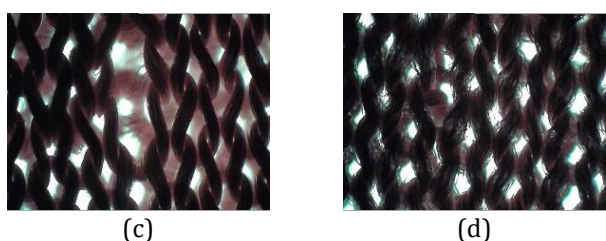


Figure 5. Microscopic views of PE fabric (c) face and (d) back



Figure 6. Microscopic views of IT fabric (g) face and (h) back

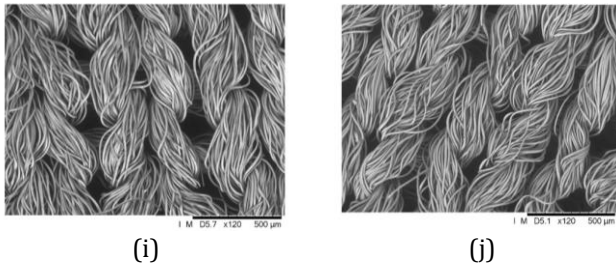


Figure 7. SEM micrographs of MM fabric (i) face and (j) back

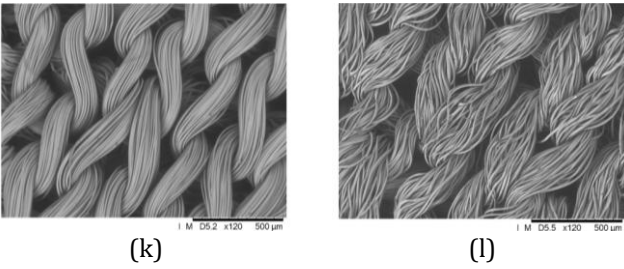


Figure 9. SEM micrographs of PE fabric (k) face and (l) back

which showed that the MM and PE fabrics were appearing with more open yarn configurations, while the EY fabric had intermediate openness structures, and the IT fabric appeared with minimal gaps, with no visible holes and dense construction.

3.4. Moisture Management Performance

The concept of moisture management describes the rate at which a fabric will move liquid from the inner surface to the outer surface of the fabric [25]. The fabrics were evaluated for their moisture management properties based on wetting time, absorption rate, maximum wetted radius, spreading speed, accumulative one-way transport index (AOTI), and overall moisture management capability (OMMC).

The results of wetting time (Figure 11) showed that all fabrics exhibited medium to very fast wetting on the top surface, with the PE fabric recording the fastest (2.92 s) and the IT fabric the slowest (9.34 s). On the bottom surface, all fabrics demonstrated fast to very fast wetting, with the IT fabric achieving rapid moisture appearance despite slower top-surface wetting.

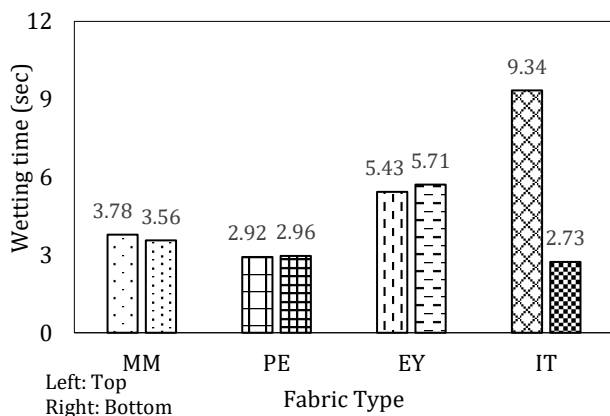


Figure 11. Wetting time (seconds)

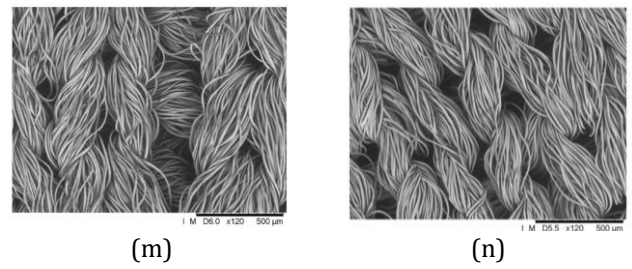


Figure 8. SEM micrographs of EY fabric (m) face and (n) back

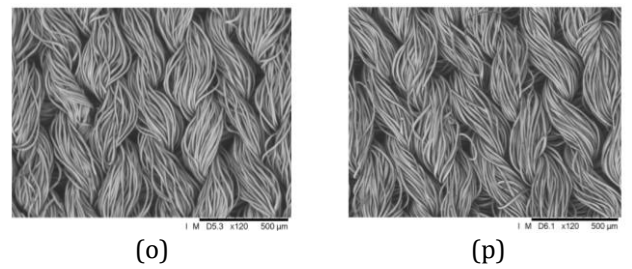


Figure 10. SEM micrographs of IT fabric (m) face and (n) back

The absorption rate (Figure 12) was generally low for all fabrics, with MM fabric showing the highest top-surface rate (21.87%/s) and EY fabric achieving the highest bottom-surface rate (39.01%/s).

Maximum wetted radius (Figure 13) showed that the PE fabric had the widest spread (22 mm top, 25 mm bottom), larger than the EY fabric. MM and IT fabrics showed moderate spreading, while the EY fabric had the smallest spread (16 mm).

Spreading speed (Figure 14) followed a similar pattern where the PE fabric showed the highest speeds (4.77 mm/s top, 5.16 mm/s bottom), faster than the EY and IT fabrics.

AOTI results (Figure 15) indicated that the IT fabric had the highest directional moisture transfer (584.92%), greater than all other fabrics, followed by the EY, MM, and PE fabrics.

The IT fabric had the highest OMMC values (0.75), followed by the EY (0.70), MM (0.62), and the PE fabrics (0.56), as shown in Figure 16.

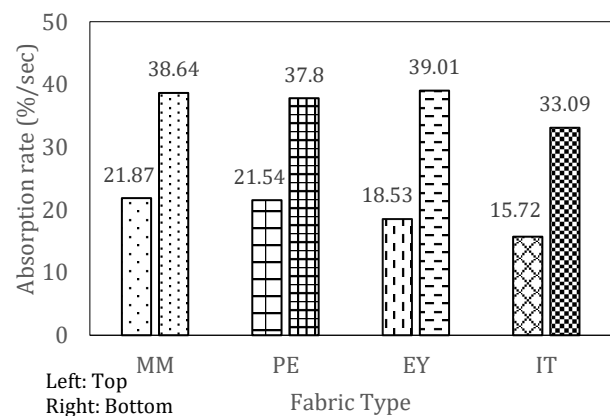


Figure 12. Absorption rate (% / seconds)

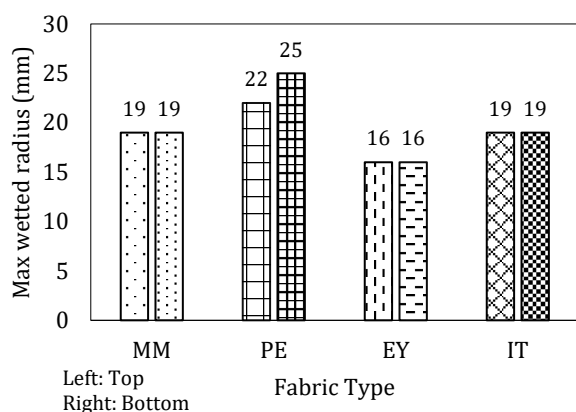


Figure 13. Maximum wetted radius (mm)

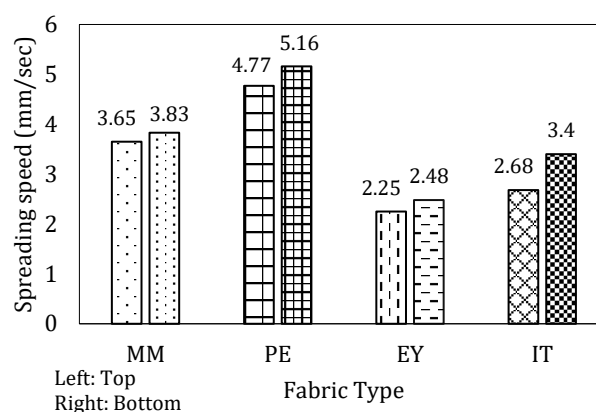


Figure 14. Spreading speed (mm/sec)

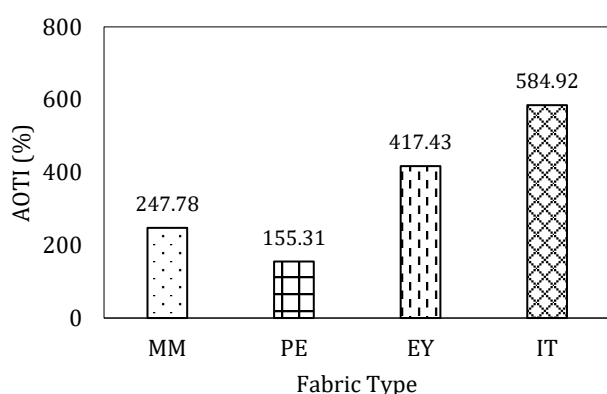


Figure 15. Accumulative one-way transport index (AOTI) (%)

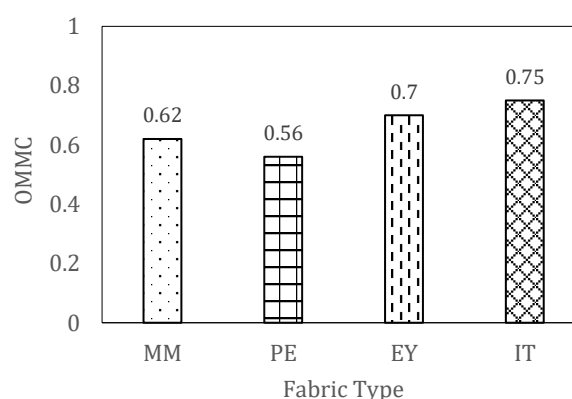


Figure 16. Overall moisture management capability (OMMC)

From the overall results, while all the fabrics are made of the same material, the differences in the fabric structures play a significant role in the moisture transport behaviour. The open structures, such as the PE fabric, enable fast surface wetting and evaporation, while the denser structures, such as the IT fabric, excel in directional moisture transport and skin dryness.

The moisture management results were generally related to the structural features of the fabrics, according to the microscopic and SEM analysis. The PE fabric with its large openings showed the fastest wetting and the largest spread, which enables fast moisture dispersion on the fabric surface [26–27]. However, the PE fabric did not perform as well as the others in directional transport. The MM fabric performed well in both aspects, while the EY fabric had moderate spread with high one-way transport due to its denser but still permeable structure [28]. The IT fabric, with its dense double-knit structure, showed the best results in AOTI and OMMC, as expected from its dense structure, which allows better moisture to transfer away from the skin [29–30]. These results support the conclusion that fabric architecture, rather than fibre chemistry, is the primary determinant of moisture behaviour, allowing sportswear design to be targeted at rapid evaporation or sustained dryness.

According to the water location in Figure 17, the moisture content on the top (inner) and the bottom (outer) surfaces

of the MM fabric after 120 seconds can be observed. The pattern of the colours on the top and the bottom surfaces was similar, with dark blue representing low moisture content and light blue representing high moisture content. The moisture content was mostly concentrated on the bottom surface, which suggested effective transfer from the skin-contact side to the outer layer of the fabric. The even spread across both surfaces highlights the good moisture absorption and efficient one-way moisture transport, supporting the MM fabric’s suitability for sportswear applications which require balanced moisture management. Earlier studies have shown that fabrics with small and evenly spaced openings tend to demonstrate balanced moisture distribution and are suitable for moisture management fabrics [31–32].

Figure 18 presents the moisture distribution on the top (inner) and bottom (outer) surfaces of the PE fabric after 120 seconds. Moisture was more concentrated on the bottom surface, showing efficient moisture transfer from the skin-contact side to the outer layer. Similar wetting times on both surfaces suggest quick and uniform wetting, while the distinct and symmetrical moisture rings reflect uniform absorption and spreading. A large moisture spread on the bottom surface shows the ability of the fabric to perform a larger overall surface distribution pattern. Therefore, the PE fabric shows quick surface wetting, very high absorption, and moderate one-way moisture transfer, which would be suitable for activities in which the quick

surface drying is advantageous to the application. Studies have highlighted that fabrics with larger apertures improve moisture transfer and evaporation rates due to their increased surface area, aligning with the observed performance of the PE fabric [12, 33].

Figure 19 presents the moisture distribution at the top (inner) and bottom (outer) surfaces of the EY fabric after 120 seconds. Both surfaces show similar circular patterns of moisture distribution, with moisture well distributed across each side of the fabric surface. The outer surface shows a slightly higher moisture concentration, which suggests the moisture has moved outwards from the base layer. The similar shape of the moisture rings and evenness of the moisture distribution suggest uniform absorption and spreading. Therefore, the balanced moisture absorption and efficient transfer to the outer layer of the EY fabric show that the EY fabric is made of properties that are suitable for sportswear, which require balanced moisture transfer and efficient drying of the outer layer of the fabric. The balanced moisture transfer and efficient transfer to the outer layer of the EY fabric meet the previous study that indicated bi-layer fabrics with intermediate porosity could provide a balance between absorption and moisture transfer. This is because the fabric structure improves the efficiency of moisture transfer from the skin-facing side to the outer layer, which is ideal for applications that require efficient moisture transfer [34].

Figure 20 shows the moisture distribution of the IT fabric after 120 seconds. There is a visible difference between the two surfaces, with the top surface of the fabric being a darker blue than the bottom surface, which indicates lower levels of moisture content. However, the bottom surface is a

darker blue, indicating a higher concentration of moisture. This is because the double-knit fabric of the IT fabric does not allow much airflow on the top surface and takes less time to dry than the bottom surface. This shows that moisture is being effectively transferred from the inner surface to the outer surface of the fabric. The moisture ring formed on the bottom surface is also larger in size, which indicates effective moisture transfer from the inner surface to the outer surface and the high one-way transport index of the fabric.

The effective moisture transfer from the inner surface to the outer surface keeps the inner surface dry. This is important for the evaporation of moisture from the outer surface. Therefore, the IT fabric is suitable for sportswear fabric. The high one-way moisture transfer of the IT fabric is consistent with the results obtained from the study of double-knit fabric. Dense fabrics, as used in the IT fabric, are known to have high moisture transfer properties. This is because these types of fabrics allow moisture to move in one direction. This results in efficient moisture transfer from the inner surface to the outer surface [13, 35].

Based on the observation of the location of water for four fabrics, the MM fabric has a good balance in absorption and distribution of moisture. Therefore, it is reliable for general moisture management. PE fabric excels in rapid surface wetting and wide surface spread, particularly on the top side, but shows moderate one-way transport. EY fabric provides uniform absorption and spreading, and IT fabric stands out for excellent one-way moisture transport, keeping the skin side drier, which is ideal for high-performance activewear, and owing to its double-knit design, which delivers high AOTI and OMMC values.

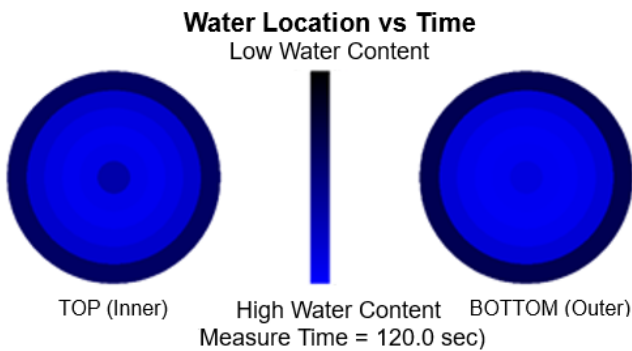


Figure 17. Water location of MM fabric

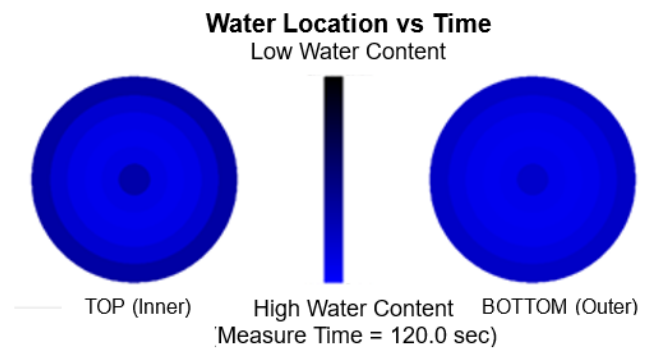


Figure 18. Water location of PE fabric

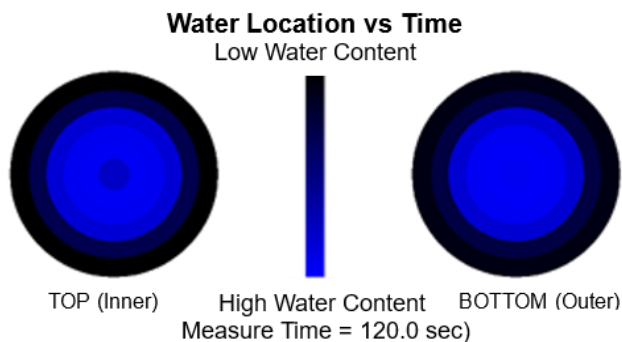


Figure 19. Water location of EY fabric

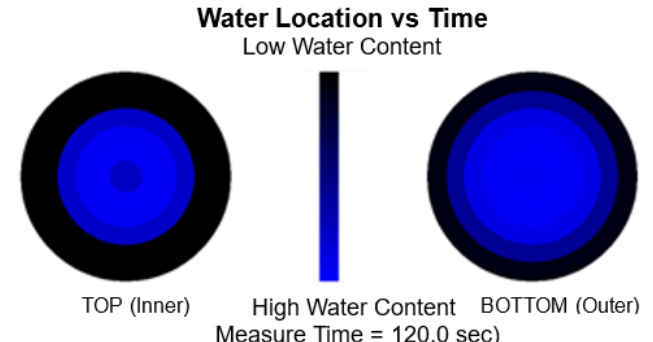


Figure 20. Water location of IT fabric

3.5. Statistical Analysis

The one-way ANOVA results (Table 2) show that fabric structure had a significant effect ($p < 0.05$) on maximum wetted radius, spreading speed, Accumulative One-way Transport Index (AOTI), and Overall Moisture Management Capability (OMMC). This indicates that the fabrics differed in their ability to disperse moisture laterally and transport it directionally. There were no significant differences in the wetting time and absorption rate, implying that the fabrics wet at the same rate as well as absorbed moisture at the same rate.

The Tukey HSD pairwise comparison, as shown in Table 3, showed significant differences ($p < 0.05$) in the maximum wetted radius, spreading speed, AOTI, and OMMC between the fabrics. Regarding the maximum wetted radius on the top surface, the PE fabric spread significantly further than the EY fabric, with the PE and EY fabrics showing 22 mm and 16 mm, respectively ($p = 0.025$). On the bottom surface, the PE fabric spread significantly further than the MM, EY, and IT fabrics, with the PE fabric showing 25 mm ($p \leq 0.011$), as expected because of the open knit structure that allows for lateral moisture movement [36]. The PE fabric also showed significantly higher spreading speeds than the EY and IT fabrics on both surfaces ($p < 0.05$), although the PE fabric and MM fabric were not significantly different.

There were significant differences in moisture transport behaviour observed among the fabrics. The IT fabric had the highest value of AOTI at 584.92%, which is better than the other fabrics in terms of the directional moisture transfer. This could be possibly related to the density of the fabric, as the IT fabric had a higher density than the other fabrics, which may promote moisture movement from the inner to the outer surface. A similar trend was observed in OMMC parameters, where the IT fabric showed the highest OMMC value at 0.75, which was followed by the EY fabric at 0.70, the MM fabric at 0.62, and the PE fabric at 0.56. However, there was no significant difference observed between the IT and EY fabrics. The high OMMC value of the IT fabric suggests that the fabric is able to balance the absorbency, spreading, and transport of the moisture, similar to the results of the study on moisture management properties in textile materials [23].

Based on the moisture management results, the PE fabric exhibited the best performance in several surface-related parameters. Although the PE fabric performed better in terms of spreading speed, quick wetting time, and maximum wetted radius, its OMMC value of 0.56 was the lowest compared to all the fabrics. This shows that although the PE fabric is good in terms of surface moisture management, it may be less efficient in achieving balanced moisture absorption through the fabric thickness. In

Table 2. One-way ANOVA of moisture management parameters of sports jersey fabrics

Fabric properties	Source of variation	df	Mean Square	F	Sig.
Wetting time (sec) (top surface)	Between Groups	3	40.501	2.250	0.122
	Within Groups	16	17.998		
	Total	19			
Wetting time (sec) (bottom surface)	Between Groups	3	9.229	1.943	0.163
	Within Groups	16	4.749		
	Total	19			
Absorption rate (%/sec) (top surface)	Between Groups	3	41.578	1.159	0.356
	Within Groups	16	35.868		
	Total	19			
Absorption rate (%/sec) (bottom surface)	Between Groups	3	37.701	1.994	0.156
	Within Groups	16	18.91		
	Total	19			
Maximum wetted radius (mm) (top surface)	Between Groups	3	30.00	3.429	0.043
	Within Groups	16	8.75		
	Total	19			
Maximum wetted radius (mm) (bottom surface)	Between Groups	3	71.25	10.364	0.000
	Within Groups	16	6.875		
	Total	19			
Spreading speed (mm/sec) (top surface)	Between Groups	3	6.288	6.215	0.005
	Within Groups	16	1.012		
	Total	19			
Spreading speed (mm/sec) (bottom surface)	Between Groups	3	6.214	9.672	0.001
	Within Groups	16	0.643		
	Total	19			
Accumulative one-way transport index (AOTI) (%)	Between Groups	3	180131.082	76.371	0.000
	Within Groups	16	2358.642		
	Total	19			
Overall Moisture Management Capability (OMMC)	Between Groups	3	0.038	32.336	0.000
	Within Groups	16	0.001		
	Total	19			

Table 3. Tukey's HSD pairwise comparison of moisture management parameters

Properties	Fabric Comparison	Mean Difference	Sig.	
Maximum wetted radius (mm) (top surface)	MM	PE	-3.00	0.404
		EY	3.00	0.404
		IT	0.00	1.000
	PE	MM	3.00	0.404
		EY	6.00*	0.025
		IT	3.00	0.404
	EY	MM	-3.00	0.404
		PE	-6.00*	0.025
		IT	-3.00	0.404
	IT	MM	0.00	1.000
		PE	-3.00	0.404
		EY	3.00	0.404
Maximum wetted radius (mm) (bottom surface)	MM	PE	-6.00*	0.011
		EY	3.00	0.305
		IT	0.00	1.000
	PE	MM	6.00*	0.011
		EY	9.00*	0.000
		IT	6.00*	0.011
	EY	MM	-3.00	0.305
		PE	-9.00*	0.000
		IT	-3.00	0.305
	IT	MM	0.00	1.000
		PE	-6.00*	0.011
		EY	3.00	0.305
Spreading speed (mm/sec) (top surface)	MM	PE	-1.13	0.321
		EY	1.40	0.166
		IT	0.96	0.453
	PE	MM	1.13	0.321
		EY	2.53*	0.005
		IT	2.09*	0.022
	EY	MM	-1.40	0.166
		PE	-2.53*	0.005
		IT	-0.44	0.902
	IT	MM	-0.96	0.453
		PE	-2.09*	0.022
		EY	0.44	0.902

Properties	Fabric Comparison	Mean Difference	Sig.	
Spreading speed (mm/sec) (bottom surface)	MM	PE	-1.33	0.077
		EY	1.35	0.074
		IT	0.43	0.833
	PE	MM	1.33	0.077
		EY	2.68*	0.000
		IT	1.76*	0.015
	EY	MM	-1.35	0.074
		PE	-2.68*	0.000
		IT	-0.92	0.304
	IT	MM	-0.43	0.833
		PE	-1.76*	0.015
		EY	0.92	0.304
Accumulative one-way transport index (AOTI) (%)	MM	PE	92.47*	0.037
		EY	-169.65*	0.000
		IT	-337.14*	0.000
	PE	MM	-92.47*	0.037
		EY	-262.12*	0.000
		IT	-429.61*	0.000
	EY	MM	169.65*	0.000
		PE	262.12*	0.000
		IT	-167.49*	0.000
	IT	MM	337.14*	0.000
		PE	429.61*	0.000
		EY	167.49*	0.000
Overall moisture management capability (OMMC)	MM	PE	0.061	0.057
		EY	-0.08*	0.007
		IT	-0.14*	0.000
	PE	MM	-0.06	0.057
		EY	-0.14*	0.000
		IT	-0.20*	0.000
	EY	MM	0.08*	0.007
		PE	0.14*	0.000
		IT	-0.05	0.123
	IT	MM	0.14*	0.000
		PE	0.20*	0.000
		EY	0.05	0.123

* Mean difference is significant at $p > 0.05$ level

contrast, the IT fabric demonstrated more consistent overall moisture performance, as reflected by its higher OMMC value compared to all the fabrics. As a result, the performance of the PE fabric should be evaluated in terms of quick surface drying and its high spreading speed and may be more suitable for applications of quick surface drying is prioritised, whereas the IT fabric offers a more balanced moisture management behaviour, which is suitable for conditions requiring efficient moisture transport and improved skin dryness.

4. CONCLUSION

In this study, the moisture management properties of four polyester microfibre sports jerseys with different knit structures, such as MM, PE, EY, and IT fabrics, were examined. The FTIR analysis showed that all of these fabrics were polyethylene terephthalate (PET), and their performance was dependent on their fabric structures. Microscopic analysis has shown variations in pore size, yarn density, and fabric construction, which directly influenced the moisture transport behaviour of the fabrics.

The moisture management tests showed that the PE fabric, with its large and open knit structure, had the fastest wetting time and the widest lateral spread. This makes it good for sportswear where rapid evaporation and ventilation are necessary. The results of the MM fabric showed a balanced moisture management performance in terms of wetting time, spreading speed, and directional moisture transfer, which supports its uses for general-purpose activewear, where moderate but effective moisture management is sufficient for the wearer to feel comfortable during exercise. Meanwhile, the EY fabric had consistent moisture distribution and strong one-way moisture transfer, while the IT fabric, with its dense double-knit structural design, excelled in AOTI and OMMC properties, which effectively transferred the moisture away from the skin and is suitable for high-intensity activities that need sustained skin dryness for the athletes. The statistical analysis confirmed that there are significant effects of fabric structure on maximum wetted radius, spreading speed, AOTI, and OMMC ($p < 0.05$) properties, although there were no effects seen on the wetting time or absorption rate.

Based on these results, it is recommended that fabric choice in sportswear should be tailored to the specific activities as well as ambient conditions. Open fabric structures such as PE fabrics should be selected for sports activities where rapid evaporation and ventilation are much needed. Dense fabric structures, such as IT fabrics, should be recommended for sports activities where high intensities are needed along with high skin dryness. Meanwhile, the MM and eyelet fabrics with their balanced performance in moisture management are recommended for multipurpose activewear, which could provide comfort across a wide range of activities. In addition to moisture management, future research should consider breathability and thermal comfort as key comfort factors that affect fabric performance during actual sports activities.

Future studies should investigate the combined effects of fabric construction and fibre modifications, including hydrophilic or hydrophobic treatments of the fabrics to further enhance directional moisture transfer. In addition, the long-term wear trials under varying weather situations would provide more realistic and accurate performance data, while integrating thermal comfort metrics with moisture management testing could yield a more complete evaluation of sportswear performance.

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