Performance Characteristics Of Warp Knitted Lining Fabrics Used For Sportswear

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Abstract: The purpose of a lining is to provide the comfort of the wearer, preserve the shape of the sportswear, conceal construction details and raw edges of fabric, thus giving a neat appearance to the inside of the sportswear. Development in sportswear lining fabrics has been progressing to perform high functions and to achieve comfort. The contributing factors for developing active sportswear lining fabrics are: fiber material, fabric structure, production techniques, lamination and finishing techniques to obtain sophisticated fiber, modified structure of yarns and fabrics. In this paper, the performance properties and various factors affecting it are discussed for sportswear lining fabrics using different constructions.

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1. Introduction

The sports fabrics are generally ultra-breathable and have high heat and moisture management properties, light weight, fast drying properties and feature elasticity properties (http://www.technicaltextile.net). These fabrics also have superior strength and durability. The latest sports textile materials are much more function for fulfilling specific needs in different sports activities. Many different aspects have to be considered when designing clothing for a particular sport (Ishtiaque, 2000); (JTN,1983);

1. The protection/safety functions to protect wearers from adverse weather (wind, rain and snow, etc).

2. The comfort function which gives wear comfort (thermo-physiological comfort, skin sensorial comfort, body movement comfort) to wearers.

3. The exercise function to assist positively improvement of athletic records and attainment of one's target.

4. Aesthetic appeal and high fashion ability.

Linings are the functional parts of the garment, being used to maintain the shape of the garment, to improve the hang and comfort by allowing it to slide over other garments, to add insulation and to cover the inside of the garment of complex construction, to make it neat. They are usually made from polyester, polyamide, acetate and viscose. Linings are used in suits, blazers, trousers, vests, skirts and dresses. For the garments where decoration or warm handle is required cotton, polyester/cotton, wool and wool mixtures can also be used (Kalaoglu and Meric, 2005).

Linings play a critical role to make sportswear more comfortable and attractive. The roles of linings are; to improve comfort in terms of thermal or wetness properties, to prevent sensory discomfort from prickliness or roughness of sportswear fabrics, to help sportswear maintain good shape or silhouette, to reduce wrinkling or residual deformation of the outer fabric and to provide durability, to reduce friction when putting on and taking off clothing and moving, to cover seams or interfacing inside lining, and to prevent transparency of the sportswear (Kawabata et al., 2001).

A variety of fabrics are available for linings. The necessary characteristics of a lining fabric are; lightweight and pliable (so it won't dominate the other fabric), soft and smooth to touch (for comfort), slick enough to slide easily on and off the body, and a firm weave to withstand wear (Tondl, 1993). It is not possible to achieve all required properties for active lining sportswear fabrics in a simple structure of any single fiber. The right type of fiber should be in the right place. The behavior of the fabric is mainly depending on its base fibers properties. The most important properties are: fiber type; fabric construction; weight or thickness of the material and presence of chemical treatments (D'Silva and Anand, 2000).

Today natural fibers are rarely used to construct linings due to high cost and some difficulties with imparting a suitable finish to fabrics. Synthetic fibers are now the most widely accepted for sportswear linings. Synthetic fibers can have either hydrophilic (wetting) surfaces or hydrophobic (non wetting) surfaces. Synthetic fabrics are generally considered to be the best choice for sportswear lining fabrics as they are able to provide a good combination of moisture management, softness, lightweight, insulation and quick drying. It is generally agreed that fabrics with moisture wicking properties can regulate body temperature, improve muscle performance and delay exhaustion (Anonymous, 1996). Polyester has outstanding dimensional stability and offer excellent resistance to dirt, alkalis, decay, mold and most common organic solvents. Being durable, yet lightweight, elasticity and a comfortable smooth feel, these are all important qualities to consumers for wide variety sportswear applications. Excellent heat resistance, good moisture transport properties, low moisture absorption, easy care properties and low cost make it very useful for lining fabrics (Adanur and Sears, 1995).

For sportswear lining fabrics (D'Silva and Anand, 2000), knitted fabrics are preferred as these fabrics have greater elasticity and stretch ability compared to woven fabrics, which provide unrestricted freedom of movement and transmission of body vapor to the next textile layer in the clothing system (Ishtiaque, 2000); (Behera et al., 2002); (Buhler and lyer, 1988). With new combinations of fabrics and yarns, and with developments in fabric construction, knitted fabric appears to be the ideal base for active lining fabrics. Knitted lining fabrics are mainly worn next to the skin and therefore deserve particular attention.

In warp knitted technology every loop in the fabric structure is formed from a separate yarn called warp mainly introduced in the longitudinal fabric direction. The most characteristic feature of the warp knitted fabric is that neighboring loops of one course are not created from the same yarn (S.Raz, 1987). The warp knitted structure is very flexible and regarding construction it can be elastic or inelastic. The mechanical properties are in many cases similar to those of woven structures. The best description of warp knitted fabrics is that they combine the technological, production and commercial advantages of woven and weft knitted fabrics (S.Raz,1994). Warp knitted fabrics can be produced continuously, elastic or stable, with an open or closed structure, they can be produced flat, tubular or three dimensional.The flexibility of warp knitting techniques makes them attractive both to the designer and the manufacturer of sportswear lining fabrics (S.Raz, 2000).

In this paper, the performance properties and various factors affecting it are discussed for sportswear lining fabrics using different constructions. The various constructions have been described along with their constitutional elements and special characteristics.

2. Material and Methods

A warp knitted structure is made up of two parts. The first is the stitch itself, which is formed by wrapping the yarn around the needle and drawing it through the previously knitted loop. This wrapping of the yarn is called an overlap. The second part of stitch formation is the length of yarn linking together the stitches and this is termed the under lap, which is formed by the lateral movement of the yarns across the needles. The length of the under lap is defined in terms of needle spaces. Warp knitting technology offers a wide range of possibilities for producing net structures, which no other technology can match.

This paper concerns with producing net wrap structures suitable for lining sportswear. In this study, six samples were produced using polyester yarns and warp knitting technique.

Fabric on Raschel machines is drawn downward from the needles almost parallel to the needle bar, at an angle of 120-160 degrees. This angle creates a high take up tension, particularly suitable for open fabric structures such as laces and nets. Table (1) shows the specification of the Rachel machine used in producing samples under study.

Table 1. The specification of the Raschel machine

Machine Type	Raschel Knitting Machine
Company	Karl Mayer
Machine Speed	1500 rpm
Machine Width	600 cm
Machine Gauge	26
No. of Guide Bar	2

Net warp knitting structures have a wide range of end-uses. One of their main uses is in sportswear lining fabrics. The Raschel machine is equipped to produce unconnected chain lapping and is thus capable of producing a multitude of net structures. Differences in net structures are the result of different loop constructions, different sizes of openings and different types of yarns. The guide bars used in the production of some warp knit fabrics are only partly threaded in a predetermined sequence, and some of the guides are empty of yarn. When this happens, openings in the fabric structure can be created and this method is used for the production of net fabrics and meshes. Table (2) shows the specification of the warp knitted lining fabrics used in producing samples under study.

Several tests were carried out in order to evaluate the produced fabrics, these are:

1- Thickness test, this test was carried out according to the ASTM D1777- 96(2011) e1.

2- Weight test, this test was carried out according to the ASTM D3776 / D3776M - 09a.

3. Absorbency test, this test was carried out according to the AATCC Test Method 79-2010.

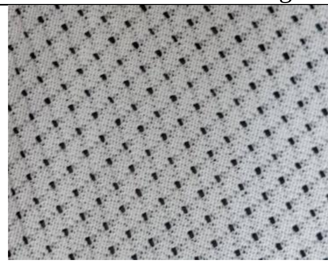
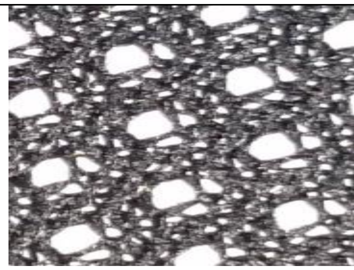
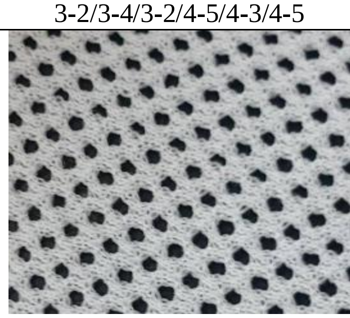
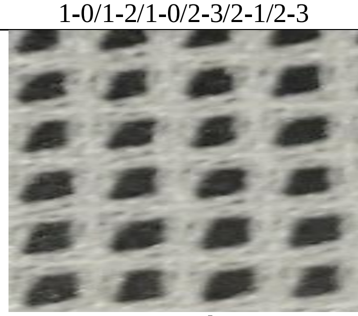
4.Water Vapor Transmission test, this test was carried out according to the ASTM E96 / E96M – 14.

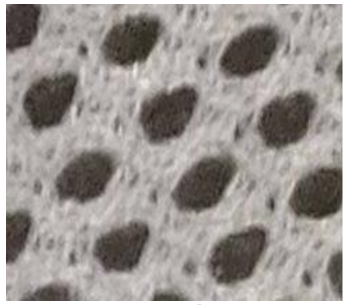
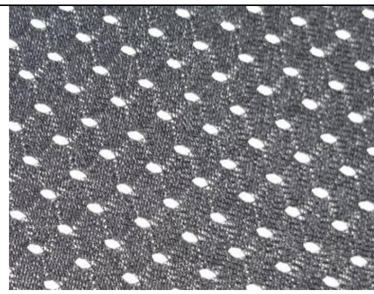
5. Thermal Transmittance test, this test was carried out according to the ASTM D:1518- 11a.

6. Air Permeability test, this test was carried out according to the ASTM D737 - 04(2012).

7. Bursting Strength test, this test was carried out according to the ASTM D3786 / D3786M – 13.

Table 2. The Specification of the Warp Knitted Lining Samples

No.	Yarn Count Denier	Fabric Structure Chain Link Numbering	Fabric Composition	Fabric Weight (g/m^2)
1	150/1 Texture Polyester	 Front Guide Bar 4-5/3-2/1-0/2-3 Back Guide Bar 1-0/2-3/4-5/3-2	100% Polyester	135
2	70/1 Flat Polyester	 Front Guide Bar 3-4/3-2/3-4/1-0/1-2/1-0 Back Guide Bar 3-2/3-4/3-2/4-5/4-3/4-5		73
3	150/1 Texture Polyester	 Front Guide Bar 2-3/2-1/2-3/1-0/1-2/1-0 Back Guide Bar 1-0/1-2/1-0/2-3/2-1/2-3		110
4	150/1 Texture Polyester	 Front Guide Bar 0-1/1-0 Back Guide Bar 0-0/1-1/0-0/3-3/2-2/3-3		98

5	70/1 Flat Polyester	 Front Guide Bar 1-0/1-2/2-3/2-1 Back Guide Bar 2-3/2-1/1-0/1-2		82
6	70/1 Flat Polyester	 Front Guide Bar 1-0/1-2/1-0/1-2/2-3/3-4/ 4-5/5-6/6-7 Back Guide Bar 6-7/6-5/6-7/6-5/5-4/4-3/3-2/2-1/1-0.		86

3. Results and discussions

There are specific physical textile properties that may be measured in an effort to predict the comfort performance of linings fabrics. Basically a textile material should be evaluated in terms of the most general functional properties: thickness, weight, thermal insulation, resistance to evaporation, air penetration and bursting strength.

3.1. Thickness

The thickness of a fabric is one of its basic properties giving information on its warmth, heaviness or stiffness in use (Saville, 2004). Samples thickness values, as shown in Figure (1), plays an important role in the other properties evaluation, such as air permeability and thermal resistance.

It is noticeable from Figure (1), that the yarn count (denier) and mesh structure are affecting differently the fabric thickness (mm). According to the structural design and yarn count, sample (1) recorded the highest thickness value (mm) while sample (2) recorded the lowest thickness value (mm). The increasing of yarn count the thickness values increasing, While knitting with longer underlaps, more yarn is fed into the fabric. It covers more wales on its way, resulting in heavier, thicker, and denser fabric.

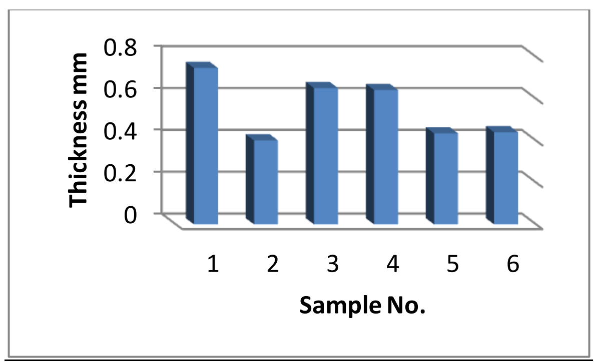


Figure 1. Samples Thickness values (mm)

3.2. Water absorption and Moisture vapour permeability

Water absorption is the capacity of a fabric to absorb the sweat generated by the body and the rate at which it is able to do so. To prevent wet clinging, the fabric's absorption should be low at the surface of the fabric which makes contact with the skin. According to the AATCC Test Method 79-2010, all samples which were made of 100% polyester don not absorb water because of its low moisture absorption. Polyester is essentially hydrophobic and does not absorb moisture, doesn't soak up sweat but is resistant to rain and reasonable insulator.

Moisture vapour permeability represents the resistance of a fabric to the transfer of water vapour, also known as insensible perspiration, released by body. Relative moisture vapour permeability is the percentage of water vapour transmitted through the fabric sample compared with the percentage of water vapour transmitted through an equivalent thickness of air. Low moisture permeability hinders the passage of perspiration through the fabric, leading to the accumulation of sweat in the clothing.

Figure (2) represents the relation between relative water vapour permeability (%) and the thickness (mm).

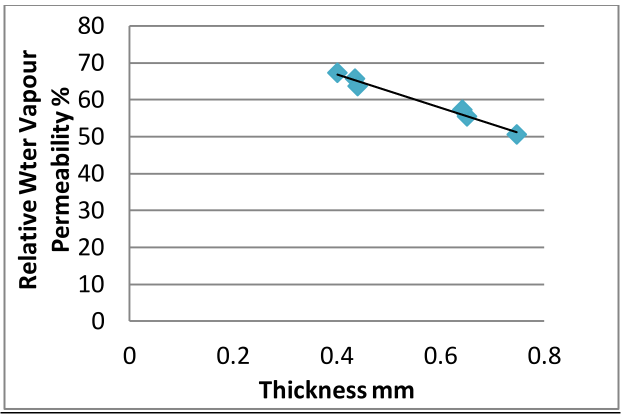


Figure 2. The Relation Between Relative Water Vapour Permeability (%) And The Thickness (mm).

$$Y=-42.301X+83.008 \quad (1)$$

From equation (1), it is clear that the relative water vapour permeability (%) is a function of knitted fabrics thickness (mm). Figure (2) shows a negative correlation between relative water vapour permeability (%) and the thickness (mm) as the rate of water vapour transmission through the fabric is reduced by increasing the fabric thickness (R^2=0.983).

For a good moisture management, textile products should present high values of water vapour permeability. With the increasing of porosity, the water vapour permeability generally increases. warp-knitted fabrics – such as nets or mesh – can help transport moisture.

3.3. Thermal Resistance

The thermal resistance of lining fabrics (tog), a measurement of how well a material resists heat flow, where the higher the TOG rating, the better the insulation. This test was carried out for all samples; Figure (3) shows the thermal resistance values (Tog) for all experimental samples.

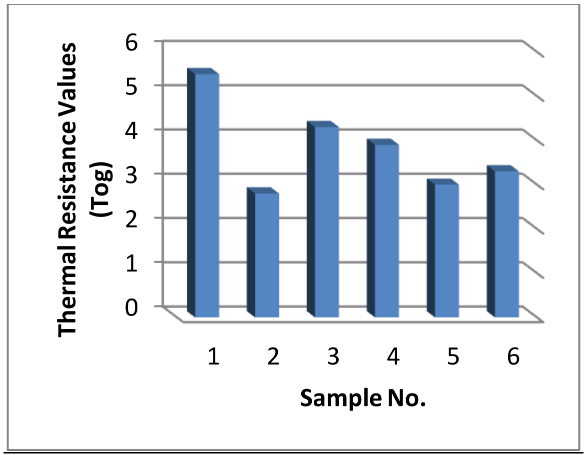


Figure 3. Samples Thermal Resistance Values (Tog)

From Figure (3), sample (1) recorded the highest thermal resistance values (Tog) while sample (2) recorded the lowest thermal resistance values (Tog). It has to be noted that the tog does not depend only on the weight or the raw material, but also on the fiber quality, the type of knitting structure, and fiber raising. Polyester has the highest thermal resistance of all the synthetic fibers; it has a melting point of between 250^{o}C and 288^{o}C.

3.4. Air permeability

Air permeability is a measure of how well air is able to flow through a fabric. The passage of air is of importance for a number of fabric end uses including the linings fabrics. This test was carried out for all samples; Figure (4) shows the relation between air permeability values (cm^3/cm^2/s) and the thickness (mm).

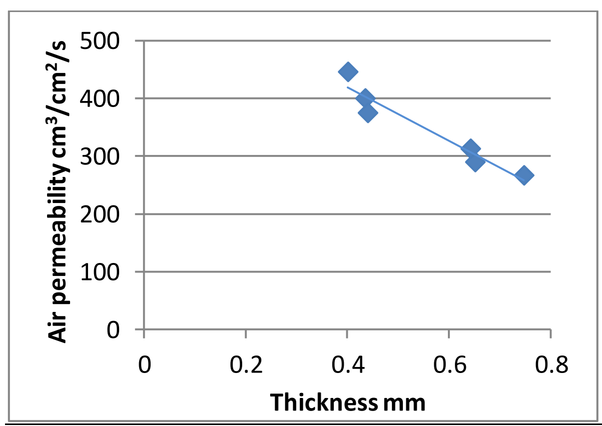


Figure 4. The Relation Between Air permeability Values (cm^3/cm^2/s) And The Thickness (mm)

$$Y=-463.88X+604.38 \quad (2)$$

From equation (2), it is clear that air permeability values (cm^3/cm^2/s) is a function of knitted fabrics thickness (mm). Figure (4) shows a negative correlation between air permeability values (cm^3/cm^2/s) and the thickness (mm) as air permeability is inversely related with fabric thickness : it decreased with increase of thickness due to increase of compactness and decrease of air space (R^2=0.9303).

3.5. Bursting Strength

Figure (5) shows the bursting strength values (Kg.f/cm^2) for all experimental samples.

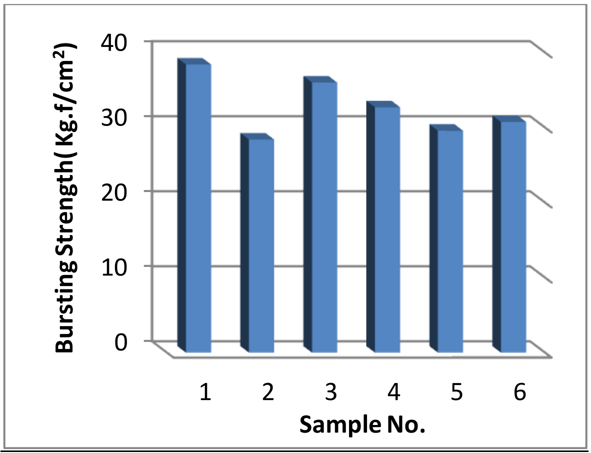


Figure 5. Samples Bursting Strength values (Kg.f/cm^2)

Strength is a measure of the coherence of a fabric, and is governed by numerous factors including the fiber type and regularity in diameter, knitted structure. From Figure (5),sample (1) recorded the highest bursting strength values (Kg.f/cm^2) while sample (2) recorded the lowest bursting strength values (Kg.f/cm^2). For the model nets, higher denier provided higher bursting strength and tension strengths. Each increase in the extent of the underlap tends to make the structure stronger, more opaque and heavier. The increasing float of the underlap has a more horizontal appearance, while overlaps produced by the same yarn will be separated from each other at successive courses by an extra wale in width.

Conclusions

Sportswear lining fabrics have functional and consumer appeal objectives. Sportswear lining fabrics developed by using special type of fibrous material, modifying fabric structure and manufacturing technology as every fibre and fabric construction has difference performance characteristics. Polyester has many performance characteristics which make it the preferable choice for sportswear linings fabrics.

Well-designed knitted meshes, have been shown to be promising for lining. A knitted mesh, as an artificial fabric, possesses many alterable factors, e.g., knitting materials, knitting techniques, and fabric characteristics. Lining thickness plays an important role in the other properties evaluation, such as air permeability and thermal resistance. The insulation resistance of lining fabrics does not depend only on the weight or the raw material, but also on the fiber quality, the type of knitting structure, and fiber raising. Knitted fabrics with unique structures and mechanical properties are an important element of the sportswear lining field.

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