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Comfort Properties of Knitted Fabrics for Sports Application

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1. Introduction

The clothing comfort includes thermo-physiological, sensorial and psychological comfort. The thermo-physiological comforts are influenced by heat exchange within clothing, air permeability and transparent evaporation of moisture. Clothing must assist the body's thermal function in such a way that the body's thermal and moisture management is balanced and a micro-climate is created next to the skin. The moisture retention may increase the weight of the garment as well as affect heat dissipation from the skin. Physiological effect is extremely important in the case of sports and active leisure wears. Synthetic fibres are not hygroscopic and therefore only absorb comparatively small amount of moisture. However, because of the hydrophilic fibre surface they have a high moisture transfer rate. The combination of natural and synthetic fibre yarns is an optimal solution to design sportswear. The aim of this paper is to comprehend the knitted fabrics and its qualities required for sports clothing.

2. Properties/Functions Required For Sportswear

- The protection/safety functions to protect wearers from adverse weather (wind, rain and snow, etc).
- The comfort function, which gives wear comfort (thermo-physiological comfort, skin sensorial comfort, body movement comfort) to wearers.
- Quick drying fabric & dimensional stability even wet.
- Freedom of movement at necessary areas in sport clothing. and prevention of the long-term feeling of dampness.
- Rapid moisture absorption and conveyance capacity and good wicking ability, air and water permeability.
- Functional properties: Active sportswear requires super lightweight, super high tenacity and stretch ability, sweats absorption, fast drying, vapour permeability and water proofing.
- Aesthetic properties: Aesthetic properties include softness, surface texture, handle, lustre, colour variation and transparency.
- Vapour transmission: To ensure the body passes vapour outward through all the layers of the clothing system.
- Heat transport performances: The sport fabrics require should maintain body temperature during various sports activities. This property makes the sportsman to feel cooler in

summer and warmer in winter. The fibrous material, bulk entrapped air within the fabric affects the heat transport properties of the sportswear.

- Moisture transport performance: By changing the cross sections of the fibre and by using special chemicals, fabrics are made with high moisture transport properties. Such fabric keeps the body dry by keeping moisture away.
- Anti-static performances: Sportswear fabrics have a very high electrical conductivity, so they can dissipate electrical charge.
- Excellent heat resistance, good moisture transport properties, low moisture absorption, easy care properties and low cost make fabric very useful for sportswear [7] [5].

3. Raw material and fabrics used for sports application

It is not possible to achieve all required properties for sportswear in a simple structure of any single fibre. The right type of fibre should be in the right place. The behaviour of the fabric is mainly depending on its base fibrous properties. The most important properties are fibre type; weave construction; weight or thickness of the material and presence of chemical treatments [6].

4. Types of knitted fabrics used

Cotton and other fibers such as polypropylene, polyester, coolmax and outlast etc., are used for making sports fabrics. Single bed and double bed knitting machines selected for the production of fabrics for manufacturing of various sports clothing. The thermo regulating effect of Coolmax relies on fibre's morphology (greater surface area and multi-channel cross section). It applies the capillary theory to rapidly remove sweat and moisture from the skin's surface, transport it to the fabric surface, and then evaporate it [1]. Combinations of cotton, polyester and carbon fibres gave sportswear fabrics with better functional properties than a single fibre type [5]. For sportswear, 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 vapour to the next textile layer in the clothing system [6].

4.1 Knitted layered fabrics

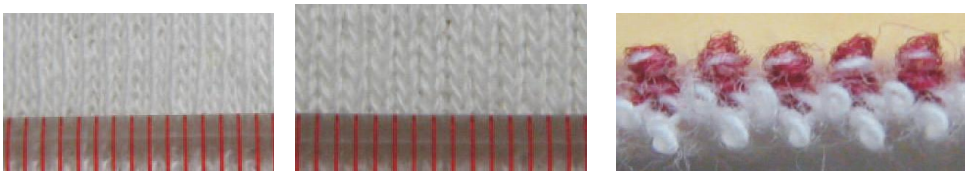
Layered fabrics became common for active sportswear. The performance of layered fabric in thermo physiological regulation is better than single layer textile structure [6]. Each layer has distinct function; the layer next to the skin is to wick away the perspiration rapidly to the outer layer, which absorbs and dissipates it rapidly to the atmosphere by evaporation. In doing so, it takes away some of the body heat and keeps the body cool. On the inside, a synthetic material with good moisture transfer properties, e.g. polyester, nylon, acrylic or polypropylene is used whereas on the outside, a material which is good absorber of moisture, e.g. cotton, wool, viscose rayon or their blends can be placed. This is the capillary effect. In another way of constructing a physiologically functional fabric is three-layer structure. The use of superfine or microfiber yarn enables production of dense fabrics leading to more

effective capillary action, with better thermo-physiological regulation. Double layered knitted fabric with two types of combined structure from cotton or man-made bamboo yarns in the outer layer and PP, PA, PES and Coolmax yarns in the inner layer[4].

4.2 Bio-mimicking knitted fabrics

Biomimetics of the branching structure of a plant can improve the water absorption and one way transport property of the fabric. Fabrics developed with such a branching structure and made from different combinations of yarns exhibited faster water absorption and improved moisture management property. The improved water absorption rate and air permeability are beneficial to clothing comfort.

In comparison with conventional structure, fabric made of biomimicking structure possess a significantly greater initial water absorption rate, one way transport capacity and air permeability which are highly beneficial to the thermal comfort of sportswear [8].



Face side of fabric Back side of fabric Cross section

Figure 1. Double bed knitted mimicking structure

5. Comfort properties required for sports application

5.1 Air permeability

Air permeability is the biophysical feature of textiles which determines the ability of air flow through the fabric. It is defined as the volume of air in millilitres which is passed in one second through 100s mm^2 of the fabric at a pressure difference of 10mm head of water.

Air permeability is a function of knitted fabric thickness and surface porosity. The pore dimension and distribution in a fabric is a function of fabric geometry. Loop length is one of the structural parameters that determine pore size in knitted fabric. When the loop length increases, the air permeability also rises. By increasing the area linear filling rate, the air permeability of fabrics increases, when the loop length increases, the course spacing and wale spacing increase as well i.e. it increases the size of pores through which the airflow permeates [2]. The yarn diameter, knitting structure, course and wale density, and yarn linear density are other main factors affecting the porosity of knitted fabrics. In sportswear, high air permeability is desirable [2]. There is a significant influence of fabric structure on air permeability. Both for Outlast and Coolmax fabrics, the lower air permeability values were characterised by higher fabric density. Structure with ribbed surface has higher air

permeability value due to their surface characteristics. Outlast fabric have higher air permeability due to lower thickness and fibre geometry. Coolmax have lower air permeability as their higher surface area increases the resistance to air flow [1]. It is emphasised that surface porosity correlates more with air permeability than knitted fabric thickness [3].

5.2 Thermal Conductivity

Thermal conductance is the quantity of heat that passes in unit time through fabric of particular area and thickness when it's opposite faces differing temperature by one Kelvin. Thermal comfort property was characterized by thermal conductivity, thermal insulation and thermal absorptivity [1].
All Outlast® fabrics have higher thermal conductivity than Coolmax® fabrics. This behaviour is influenced by the yarn characteristics and by the fabric structure. Structure with 3-needle floats has the lowest thermal conductivity and structures with one-needle floats and double locknit has the highest thermal conductivity.

5.3 Moisture management property

For liquid transport within fabrics, two phenomena must be accounted: wet ability and wick ability. The term 'wetting' is usually used to describe the change from a solid–air interface to a solid–liquid interface. Wicking is the spontaneous flow of a liquid in a porous substrate, driven by capillary forces.
Fabric wick ability mainly depends upon the fabric construction, yarn regularity and the type of fibre and its characteristics. The wick ability of tencel layered polypropylene fabric is higher than the cotton layered polypropylene fabric because tencel fibre has smooth yarn surface which leads to good capillary action.

The diffusion ability behaviour is essentially related with characteristics and nature of yarn (hydrophilic or hydrophobic character), and to a certain extent, with the fabric characteristics and structure. In the Outlast® fabrics the hydrophilic character of the cellulose-based fibres is the most influencing factor of diffusion ability. In the Coolmax® fabrics, the hygroscopic character and special morphology of the fibre are the main factors promoting water diffusion. Fabric characteristics and structure are determining factors of the amount of water up-take. For both Coolmax® and Outlast® fabrics, the initial wicking rate is higher for ribbed structures single jersey. Locknit structures with the highest bulk density and relatively high thickness have the worse wicking ability [1].

5.4 Water Vapour Permeability

When vapour passes through a textile layer two processes are involved: diffusion and sorption-desorption. At a specific concentration gradient, the diffusion rate along the textile material depends on the porosity of the material and also on the water vapour diffusivity of the fibre. Diffusivity of the material increases with the increase in moisture regain and hygroscopicity of the material. In low density open textiles, moisture vapour transport property is determined by knitted fabric thickness and construction. Fibre-related factors,

such as cross-sectional shape and moisture absorbing properties, do not play a significant role [1].

Outlast® fabrics have higher water vapour permeability than Coolmax® fabrics due to its higher vapour diffusivity. Moreover, the cross-sectional shape of Coolmax® fibre increases the resistance to vapour flow through the fibre surface, which reduces water vapour permeability. Structures with the highest fabric densities showed the lowest indexes of water vapour transmission rate.

Clothing made from micro porous membrane bonded with (or applied on)knitted fabric, shows good water-tightness and a low water vapour permeability through the composite system and consequently particularly beneficial hygienic properties and high comfort of use. Clothing made from multi-layer composite materials containing hydrophilic membranes with compact structure is characterised by high water-tightness and high water vapour permeability at the same time[4].

The lack of surface porosity has influence on water vapour permeability and contrast influence on air permeability. Water vapour permeability takes place in conditions of free convection but air permeability affect convection, where large surface of clearance is good for air transport [3].

5.5 Water absorbency

Water absorbency is mainly depends upon the porosity of fabric and the type of fibre and yarn. Liquids spot dynamics are influenced by the raw material, the course and wale density and knitting structure. Tencel layer polypropylene fabric has quicker absorbency than cotton layer polypropylene fabric because tencel is a regenerated cellulosic fibre, it is having uniform structure and the porosity of the fabric is higher than cotton. It leads to allowing the water particles as earliest.

Coolmax threads absorb water faster than those knitted fabric from a combination of PA, PES and PP threads [2]. The area of liquid spot on the fabrics knitted from cotton and synthetic yarn combination is greater than in case of fabrics knitted from man-made bamboo and synthetic yarn combination. The greater area of liquid spot the fabric will dry more rapidly [2].

6. Conclusion

The comfort properties required for sports fabric elaborated. The various factors influence the knitted fabric property also discussed. The raw material used, fabric structure and finishing given to the fabric also influencing factor for the various performance of the fabric. The sports performance is based on the efficiency of sports person and the characteristics of fabrics used to make sports clothing. Based on the review discussed the proper selection and design of knitted fabric is very important for manufacturing of sports garment.

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