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Application of textile fibres for technical and performance enhancements in sports

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Abstract
Technical textiles enable the production of materials which are stronger, breathe like skin, waterproof like rubber and at the same time eco – friendly and highly economical. Sportswear textiles belong to a category called sport tech, which is one of the mainstream technical textiles. This rising interest is due to a number of social factors that include increased leisure time, increased considerations of wellbeing and good health, growth of indoor and outdoor sports facilities and the ever-increasing pursuit of the adult population of activities outside the home or workplace. The revolutionary new textiles used in sports and leisure industry are popularly known as sports textiles. Today sports demand high performance equipment and apparel. In recent years, development in active sportswear fabrics has been progressing to perform high functions and to achieve comfort. The contributing factors for developing active sportswear fabrics are: polymer science, fibre science, production techniques, lamination and finishing techniques to obtain sophisticated fibre, modified structure of yarns and fabrics.

Keywords: leisure, active sports, high performance fabric and comfort properties

1. Introduction
Technical textiles are textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics. There are 12 main application areas of technical textiles and sports tech is one of the 12 main application areas. More healthy lifestyles are leading to greater sports participation, more sports have been invented and many old sports have become popular. The active wear and sportswear sector of the textiles industry is extremely broad. It can range from specialist sports apparel worn by professional athletes, to sportswear worn by everyday consumers for its fashion value. In active and endurance sports, the performance of a sportswear is synonymous with its comfort characteristics. A multitude of end-uses for sports and active wear requires a similarly broad range of functional properties. For example, wind proofing and high thermal insulation are required for skiwear, whereas efficient thermoregulation and moisture management are useful in football shirts. The diversity of applications and the fashion appeal of sportswear and active wear has fuelled its tremendous growth over the last few years. Nowadays consumers demand higher levels of comfort, design and easy care in all types of clothing.

2. Comfort characteristics required for sportswear
There are four basic types of comfort
1. Thermo physiological Comfort
2. Sensorial / Tactile Comfort
3. Mobility / Dexterity
4. Psychological Comfort

2.1 Thermo physiological comfort
This form of comfort may be said to exist when the person is in thermal balance (i.e.) when the rate of loss of heat from the body equals to the rate at which it is being generated by the physiological processes.

2.2 Sensorial / Tactile comfort
The Sensorial Comfort does not directly involve any temperature balance, but is related to the way that the person feels when clothing is worn next to skin. Sensorial comfort is mainly determined by the fabric surface structure and to some extent, by moisture transport and buffering capacity. It is associated with skin contact sensations and is often expressed as feelings of softness, smoothness, clamminess, clinginess, prickliness and the like.

2.3 Mobility / Dexterity
While doing the various physical activities in the active sports, considerable movement of body parts occur. The sportswear must therefore have sufficient degree of mobility so that wearer can be able to move freely.

2.4 Psychological comfort
Thermo physiological comfort has two distinct phases. During normal wear, insensible perspiration is continuously generated by the body. Steady-state heat and moisture vapor fluxes are thus created and must be gradually dissipated to maintain thermoregulation and a feeling of thermal comfort. The clothing becomes a part of the steady-state thermoregulatory system in this case.

3. Comfort related textile properties
There are specific physical textile properties that may be measured in an effort to predict the comfort performance of fabric. They are
- Thermal insulation
- Thermal conductivity
- Moisture vapour permeability
- Water absorption
- Wicking, Air permeability
- Rate of drying
- Surface coefficient of friction

- Handle
- Anti-microbial, anti-bacterial and anti- odor properties

Table 1: Comfort and textile properties

Textile properties	Definition
Thermal insulation	Thermal insulation is the resistance of a fabric and the layer of air next to it during use to dry or conductive heat loss
Thermal conductivity	The thermal conductivity of a fabric is determined by the rate of transmission of heat through fabric
Moisture vapour permeability	Moisture vapour permeability represents the resistance of a fabric to the transfer of water vapour, also known as insensible perspiration, released by body
Water absorption	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
Wicking	Wicking is the capacity of a fabric to transport absorbed sweat away from the point of absorption, usually the skin and the rate at which it does so
Air permeability	Air permeability is a measure of how well air is able to flow through a fabric
Rate of drying	The rate of drying is the rate at which water is evaporated from the outer surface of a fabric
Surface coefficient of friction	The surface coefficient of friction of a fabric contributes to its sensory comfort. The coefficient of friction usually increases significantly when a fabric has become wet, leading to rubbing or chafing of the skin
Handle	The term handle describes the tactile qualities of a garment. It includes such properties as softness, compressibility, pliability and drape
Anti-microbial, anti-bacterial and anti-odour properties	Anti-microbial, anti-bacterial and anti-odour properties are important in garments which tend to remain in contact with sweat for long periods of time

4. Characteristics of sportswear

1. Optimum heat and moisture regulation
2. Good air permeability
3. Wick ability
4. Dimensional stability even after wet
5. Durable
6. Easy care and Light weight
7. Soft and pleasant touch and produces cooling effect.

5. Fibres

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 behavior of the fabric is mainly depending on its base fibres properties.

5.1 Common Fibres

5.1.1 Polyester

Polyester has outstanding dimensional stability and offer excellent resistance to dirt, Alkalies, decay, Mold and most common organic solvents. Excellent heat resistance or thermal stability is also an attribute of polyester. It is the fibre used It is the fibre used most commonly in base fabrics for active wear because of its low moisture absorption, easy care properties and low cost. Polyester is essentially hydrophobic and does not absorb moisture. However, most polyester used in base layer clothing is chemically treated so that they are able to wick moisture.

5.1.2 Polypropylene

Polypropylene cannot wick liquid moisture. However, moisture vapour can still be forced through polypropylene fabric by body heat. Polypropylene has the advantage of providing insulation when wet it can melt at medium heat in home dryers. Polypropylene is claimed to be a proved performer in moisture management due to its hydrophobic nature and has very good thermal characteristics, keeping the wearer warm in cold weather and cold in warm weather.

5.1.3 Nylon

Nylon fibre characteristic include lightweight, high strength and softness with good durability. Nylon also quickly when wet. Nylon is good fabric choice when combined with PU coatings. Nylon has a much higher moisture regain than polyester and therefore has better wicking behaviour. It is most often used in tightly woven outerwear, which can trap heat because of low air permeability. It is also used in more breathable knitted fabrics, where it can perform well.

5.1.4 Cotton

Cotton garments provide a good combination of softness and comfort. However, cotton is not recommended for use in base layer clothing because of its tendency to absorb and retain moisture. When wet, cotton garments cling to the skin causing discomfort. During SASMIRA's trials for wicking of cotton treated with hydrophobic finishes showed good wicking properties.

5.1.5 Viscose rayon

The viscose rayon is not preferred next to skin as it holds water (13 % moisture regain) in sportswear. The outer layer of knitted hydrophilic portion of the twin layer Sportswear can be of viscose rayon, which absorbs 2-3 times more moisture than cotton. The wicking behaviour improves by incorporation of some hydrophobic finishes.

Table 2: Comparison of textile fibres

S. No	Fibres	Moisture Content (%)	Density (gm/cc)	Tenacity (g/d)	Melting Point (°C)	Elongation (%)	
						Dry	Wet
1	Cotton	8.5%	1.54	27 dry, 30 wet.	--	5-10	
2	Viscose	11%	1.52	2.6	--	15	25
3	Polyester	0.4%	1.38	3 – 10	260	10	
4	Polypropylene	0.01%	0.9	2 – 5	160	5	

5.2 Special Fibres

5.2.1 Hygra 20

Unitika Limited has launched Hygra, which is a sheath core type filament yarn composed of fibre made from water absorbing polymer and nylon. The water-absorbing polymer has a special network structure that absorbs 35 times its own weight of water and offers quick releasing properties that the conventional water absorbing polymer cannot do. Hygra also has superior antistatic properties even under low wet conditions. The main apparel applications include sportswear like athletic wear, skiwear, golf wear etc.

5.2.2 Killat N23

Killat N from Kanebo Ltd is a nylon hollow filament. The hollow portion is about 33 per cent of the cross section of each filament due to which it gives good water absorbency and warmth retentive property. The manufacturing technology of Killat N is very interesting. The yarn is spun as bicomponent filament yarn with soluble polyester copolymer as the core portion and nylon as the skin portion.

5.2.3 Lycra25

Lycra, a truly synthetic fibre of long chain polymer composed of at least 85% segmented polyurethane, finds wide range of end users such as swimwear, active sportswear, floor gymnastics because of its comfort and fit2O. Adding Lycra to a fabric gives it stretch and recovery, particularly in gymnastics and swimwear where body skin flexing and stretching are inevitable. Lycra T-9026 requires still effort for the same extensibility.

5.2.4 Dacron

4-Channel Polyester a generic term for a high performance four channel fibre engineered to move moisture and speed the evaporation of perspiration. It is a superior fabric for wicking action, drying time, moisture absorption and transport.

5.3 Regenerated Fibres

5.3.1 Tencel

Tencel is the generic name of Lyocell. Lyocell is a natural, manmade fibre produced in an environment friendly process from wood pulp that has become popular in clothing. The moisture management of tencel is unique when compared to synthetic fibres and allows for peak performances in sports. The excellent moisture absorption is perfect for the skin and thus guarantees wellbeing at a very high level.

5.3.2 Bamboo

Bamboo fabrics are made from pure bamboo fibre yarns which have excellent wet permeability, moisture vapour transmission property, soft hand, better drape, easy dyeing, splendid colours. It is newly founded, great prospective green fabric. Bamboo fibre has a unique function of anti-bacteria, which is suitable to make underwear, tight t- shirt and socks. Its anti – ultraviolet nature is suitable to make summer clothing.

5.3.3 Soybean

Soybean protein contained in the fibre remakes a superior, soft hand endowed with both moisture absorbency and permeability, which makes best application in knits and innerwear. Finishes with an antibacterial agent, health-care functionalities are also given. It has great potential in its use in high-grade knits and innerwear.

6. Yarns

Three major yarn production systems are

- Ring spinning
- Rotor spinning
- Vortex spinning

6.1 Ring Spinning

Ring spinning is a continuous spinning system in which twist is inserted into a yarn by a tiny circulating traveller. Yarn twist insertion and winding take place simultaneously. Ring yarn structure generally accepted as the basic structure in spun yarn technology. Ring spun yarn is usually assumed to have an ideal cylindrical helical structure uniforms specific volume and each helix having the same number of turns per unit length. The average helix angle of fibers in ring spun yarn was found to be 17.2°.While noticing the configurations of tracer fibres of ring spun yarn, it was observed that the helix angle varies along the length of the fibres confirming the presence of definite fiber migration in the yarn structure.

6.2 Rotor Spinning

In rotor spinning, fibers bundle from the sliver feed stock are separated into individual fibers with an opening roller in an air stream and separated fibers are re-collected in the rotor groove. Many open-end spinning methods have been invented, but none have been successful than rotor spinning. In rotor spinning the Production rate are up to 200 mpm, this can be achieved for yarn counts up to 20 Tex. The rotor spun yarn shows a bipartite structure (two-zone structures) comprising a core of fibres this are aligned with the helix of the inserted twist and form the bulk of the yarn, than an outer zone of wrapper fibres, which occurs irregularly along the core length. The wrapper fibres are classified into two types, short and long wrappers.

The average helix angle of fibres in rotor spun yarn is significantly higher than that of rings spun yarns. This is because, for same yarn count, rotor yarn demands more TM than the ring yarn to keep the end breakage rate at a lower level. The higher average yarn diameter of rotor spun yarn compared to ring spun yarn signifies that fibres are loosely packed in rotor yarn. In spite of higher TM, high bulk of rotor yarn can be attributed to the more number of folded fibres, which need extra volume, and less spinning tension in rotor spinning as compared to the ring spinning. In addition, the different twist in order yarn structure also increase the bulk because of the extra volume brought about by crossing fibres. Rotor yarns are less irregular than the ring spun yarn because of multiple doubling or back doubling of

fibres in the rotor groove and ultimate thickness of rotor spun yarn is made up of many thin layers of fibres. Moreover, rotor spun yarns, being made from sliver and with opening roller drafting, are not as affected by roller drafting wave as ring yarns. However, in this experimentation the 30's Ne rotor spun yarn results with high imperfection due to less back doubling than the courser count yarn.

6.3 Vortex Spinning

The Murata vortex spinning is based on the air jet spinning technology which used for a wider range of fiber length. In the vortex system, drafted fibers are introduced into a spindle

orifice by an air vortex. While entering and passing through the orifice, fibers are twisted by the swirling air. It can deliver yarn at up to 400 mpm. A visual observation of the yarns shows that the fibers, which form the body of the yarn, lie parallel along the helix of twist. The vortex spun yarn has a two-part structure (core and sheath). MVS spinning technology is favourable for cotton spinning and produces a yarn with more rings –like appearance than MJS spinning technology. This can be simply revealed by untwisting a vortex yarn by hand. None of the conventional twist measurement methods is suitable for the rotor and air vortex yarns. In studies on 36's Ne P/C blend, vortex yarns exhibit lower elongation than the air jet yarns. This offset gains in tenacity and resulted in an insignificant difference in the work of rupture.

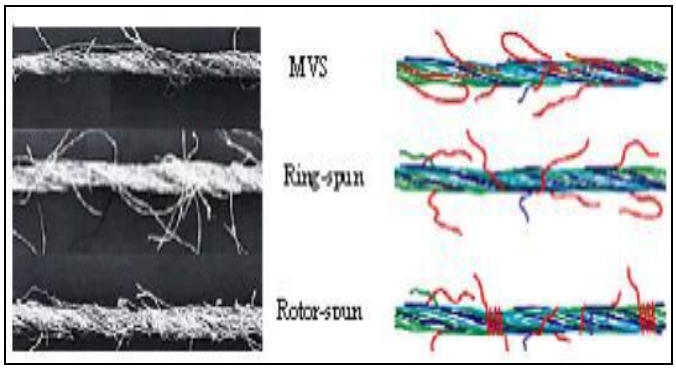

Fig 1: Ring, rotor and vortex yarn structure

7. Types of fabrics used in sportswear

- A wide range of woven, knitted and nonwoven fabrics are commercially available for sportswear.
- These fabrics differ in their structure such as entrapped air, pore shape and size, bulk and surface properties etc. which may affect the heat and moisture transmission characteristics of the fabrics.

Generally, 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. With new combinations of fabrics and yarns, and with developments in fabric construction, knitted fabric appears to be the ideal base for active sportswear. Knitted garments are mainly worn next to the skin and therefore deserve particular attention. But the major problem in both woven and knitted fabrics is that, owing to sweat generation, the fabric tends to stick with the body of the athlete resulting in discomfort during his running. The term "sportswear" refers to any garment specially designed for use in sport activities.

In order to maximize the athlete's performance, the sportswear must be efficient, essentially, in body thermoregulation and moisture management. All these factors are dependent on the fibrous materials and structures used.

7.1 Water Proof Breathable Fabrics

In the last few years, the requirement of fabrics are: lightweight, but durable; waterproof, but breathable and soft but more resistant. In this way, "smart fabrics" appeared to answer to some of these requirements. These fabrics were designed and developed to maximize the benefits of physical activity and minimize their possible drawbacks.

Fig 2: Water proof breathable fabrics

Fibrous structures used in the production of more casual wear are of elastic type, in order to ensure an unlimited freedom of movement and carry moisture from the body to the next fibrous layers. With the right combination of fibers, yarns and technology, it is possible to produce ideal structures for functional sportswear.

7.2 Layered Fabrics

A fabric which is made up of one or more layers is called layered fabric. The performance of layered fabric in thermo-physiological regulation is better than single layer textile structure.

The fabrics for Active wear and sportswear are also specially

constructed in terms of the geometry, packing density and structure of the constituent fibres in yarns as well as the construction of the fabric in order to achieve the necessary dissipation of heat and moisture at high metabolic rates

8. Sportswear for different types of sports
8.1 Cricket
8.1.1 Body movements of a cricket player
8.1.1.1 Batting

Fig 3: Batting Movements

8.1.1.2 Bowling

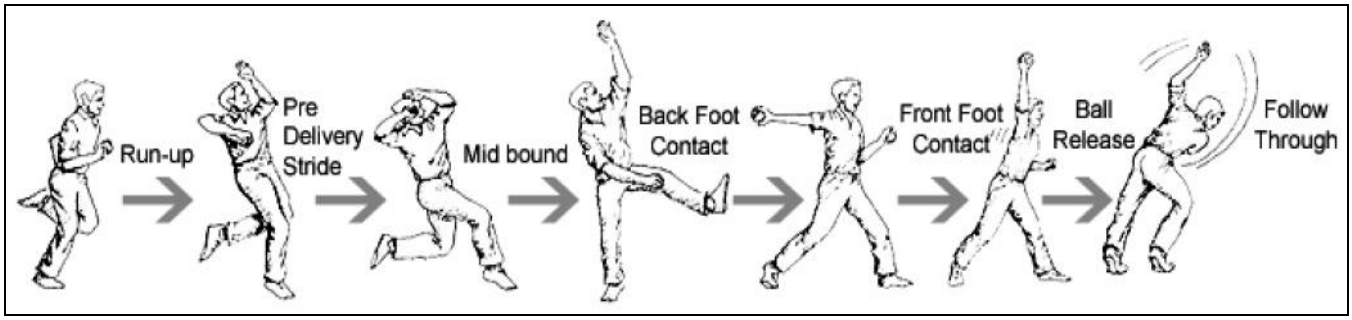

Fig 4: Bowling Movements

8.1.2 Properties required for a sportswear of cricket player

- Sweat absorbing
- Fast drying
- Cooling
- Wicking ability

8.1.3 Sportswear for a cricket player

Table 3

Fibres	**Cotton** 1. Absorbs high levels of moisture and retain it 2. The wicking property between inner and outer surfaces of the fabrics made of cotton fibres is very poor. 3. When cotton becomes wet, it dries out slowly.This can lead to rapid and undesired heat loss once activity has stopped. 4. Absorption of moisture also leads to an increase in the weight of the garment and this may impair sporting performance, cotton fabrics are easier to clean than those based on many synthetic fibres
	Polyester 1. Polyester has outstanding dimensional stability and offer excellent resistance to dirt, alkalis, decay, mold and most common organic solvents. 2. Durable, yet lightweight, possess good elasticity and a comfortable smooth feel. 3. Excellent heat resistance, good moisture transport properties, low moisture absorption, easy care properties and low cost. 4. Its wicking rate, although slow compared with other synthetic fibres, is faster than that of cotton. Polyester has high strength, and no loss of strength when wet.
Yarns	**Vortex yarns** 1. The yarn is less hairy and hence has a more clear appearance 2. Higher resistance to pilling in comparision with other type of yarns 3. The unique yarn structure has higher moisture absorption capacity and gives dry fit feeling making it suitable for sports wear 4. After repeated washes the yarn is hardly prone to lint, skewness and colour fading making the fabric highly durable.
Fabric	**Bilayered fabric** Each layer in Bi-layered fabric has distinct function ▪ **Inner layer (polyester/cotton)** which is next to the skin wicks away the perspiration rapidly, thereby, takes away some of the

	body heat, keeps the body cool and dry. It is called as base layer or first layer. ▪ **Outer layer (polyester)** absorbs and dissipates the sweat rapidly to the atmosphere byevaporation. Knitted and woven fabrics can be used as bilayer fabrics, where the spatially separate components forming the inner and outer layers are linked by the overlapping yarns. All the parameters of the two components can be selected freely and largely independently from one another.

9. Conclusion

Sportswear manufacturers have intensified competition in the pursuit of functions. During these recent several years, sportswear has taken on a new look as lifestyle wear. Accordingly, function required for sportswear on the whole has changed to meet these requirements. The demand of the times is functions with comfort in mind. A bilayered knitted fabric structure made of air vortex yarn who inner layer is made up of a blend of 65%polyester and 35%cotton to give sensorial comfort to wearer and to give better absorbency of sweat with outer layer made up of 100% polyester to give better wicking and fast drying properties can be suitable for a sports wear used by a cricket player.

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