Application of Textiles in active Sportswear

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Abstract: *India is appearing as an important market for Technical textiles. The textiles used in sports are one of the fast-growing sectors of Technical Textile which add about 9% of the technical market. Consumers demand a high level of comfort, design and easy care, not only used in daily wear but also activewear and sportswear. The efficiency of the athlete can be improved by specialized `textiles like compression activewear and biomimetic swimwear. Specialized merchandises are regularly being developed where generally act, quality and design are the important parameters. The present article addresses the practical and aesthetical requirements of high activity sportswear, thermo-physiological comfort, and the latest development in fibers, yarns, and fabric structure. Further, special finishes applied to sportswear, characteristics of sportswear, moisture management, multi-layer fabric, evaluation of active sportswear are also summarized.*

Keywords: Textiles, sports, moisture management, thermal comfort, fabric structures

Introduction

Sports textile is a branch of technical textiles which deals with the textile materials used in sports [1]. in the 21st century, clothing is a vital thing for general consumers and active athletes[2], The growth in activewear and sportswear market has a significant impact on the textile industry[3], includes special apparel for particular sport with its particular functions.

The sports textiles are using the advantage of the latest smart technology [4], the sports industry has the highest market share of smart textiles[5,6]. The anticipated growing demand for sports textiles and fitness industry has been increased by 33 % from 2015 to 2023.[7,8]

The properties of sports textiles materials will claim various requirements from their respective fibers and fabrics, at the same time they should accomplish the customer demands such as fit, drape, and ease of motion [2,3,9]. Active sports are those one should be played for a short time with a high physical effort like soccer, tennis, jumping, running, etc. The performance of a sportsperson is affected by sportswear so it becomes an important factor [10]. The sports fabrics are generally lightweight, high tenacity, stretchable, moisture vapor permeability, heat regulation, dimensional stability, quick-drying nature, waterproof, UV resistance [3], soft, non-abrasive and easy care [2], good perspiration fastness, the minimum level of bacteria [9]. highly ventilated, heat, moisture management, ultra-light weight, elastic and rapid drying properties [2], these properties are generally affected by the fiber properties [11]. In high dynamic sports like tennis and soccer, heat pressure is of incredible increase because of the abnormal state of metabolism, warmth rage which is in the scope of 800 - 1300W. This measure of warmth can expand the body center temperature by 1.5 – 2ºC. To control the center temperature of the body, sweat age happens and warmth of vaporization of water is utilized to give the cooling impact. Sweat range can go as high as 2.5L/h and consequently the primary practical prerequisite of high dynamic sportswear is sweat engrossing, quick-drying and cooling [10]. Further, moisture management property plays an important role in high active sports, which tells about the comfort characteristics of that fabric. Athletes sweat while performing various activities, transportation of sweat out of the body is a vital feature of fabric, to make the wearer feel comfortable. Therefore, moisture management is expressed as the controlled transfer of perspiration from athlete skin to air through sportswear [12].

Thermal Comfort of Sportswear

Comfort is defined as a pleasant state of physical and mental harmony between men and nature, has become the most significant feature along with the developments in textile technology.[13]

This parameter has 4 considerations: sensorial, psychological, thermophysiological and body movement

- Psychological comfort indicates that people need specific garments, fabrics, colors, and design features to make them feel comfortable. fabrics used while high strenuous activity, psychological comfort additionally happens when the fabric is extensible and doesn't limit versatility. [3]
- Sensorial comfort manages the mechanical sensations brought about by materials for what it's worth in direct touch with the body. fabrics should be pliable and soft when wearer uses and especially during damp, should not irritate the wearer. To an extent, sensorial comfort can be increased by the control of smell and by the utilization of UV repellent materials. Waterproofing can increase sensorial comfort but may impede thermophysiological comfort. [3]
- The thermal comfort is influenced by properties like thermal, moisture and air permeability. This involves warmth and dampness transport forms through the garments and legitimately impacts an individual's thermoregulation. Thermal interaction among man and environment exceptionally mind-boggling, because the person's perception of thermal comfort is influenced by many factors, such as humidity, air movement (speed), clothing, air temperature, activity level & other factors [3,6]
- during the working condition, the human body is at 37ºC, which endeavors to keep up under changing conditions. During substantial exercises, the body creates heaps of warmth vitality and the body temperature rises. Thus, it is necessary to transport heat from the body to the environment to regulate body temperature at 37ºC. To maintain the temperature, the body perspires in vapor and liquid form.[3,8]

Fibers for sportswear

Cotton

cotton fibers provide the best combination of comfort and softness [9]. Trials done by SASMIRA's on wicking behavior of cotton which is treated with hydrophobic finishes shows excellent wicking behavior. cotton is not suggested to use in base layer as it holds moisture and in wet condition, cotton garments stick to the skin which causes inconvenience [3,9,14], and Cotton has properties like slow to dry and cold when wet, which is not suitable for use against the skin during strenuous activity.

wool

Wool has the best wicking character, highest moisture regain and is the best insulator at the wet condition. However, wool takes more time to dry. Superfine Merino wool has superior water vapor permeability and rapid drying capability. Merino wool fibers can be blended with other fibers like silk, viscose, Tencel, polyester, polyamide. All grades of wool are not suggested for the base layer of fabric, as it is next to skin, it shouldn't irritate the human. The "itch" so generally observed in wool fabrics which results from the fiber ends itching. Thus, staple fibers are more tingle than long fibers because more fiber finishes are contacting your skin. Secondly, the fiber should be finer. This takes into consideration a texture of high fiber thickness to be made, which builds quality and scraped spot obstruction notwithstanding expanding the air development between and contiguous pockets of dead air space in the texture. Finally, fine fibers will absorb low water per unit area, as they are more flexible than coarse fibers. The efficiency of wicking is also more with a fine fibered fabric that has more fibers can be packed into a given space than an equal volume of coarse fibers [14].

Regenerated fibers

Regenerated fibers manufactured from natural sources tend to be highly absorbent. Tencel is the brand name for a kind of lyocell manufactured by Lenzing, made by using the wood pulp. It has a great absorption capacity, an exceptional nano-fiber structure with a smooth surface. It is a soft but stronger fiber than cotton both wet and dry, that is resistant to wear and tear for clothing. Regenerated fibers are mixed well with other fibers, both natural and man-made. They are ultra-soft and comfortable in making them the best choice for the base layers in sportswear. [3]

Viscose rayon is not preferred next to the human body as it has moisture content in it. The outmost layer of the knitted hydrophilic portion of the multilayer Sportswear can be made of viscose rayon, which absorbs 2-3 times more moisture content than cotton. The wicking property can be increased by using some hydrophobic finishes [9].

Synthetic fibers

Synthetic fibers are widely chosen for sportswear [3]. man-made fibers can be either hydrophobic or hydrophilic surfaces. Man-made fabrics are commonly considered as the best decision for activewear as

they are capable to produce the best combination of insulation, softness, lightweight, moisture management and quick-drying. It is commonly known that fabrics with moisture absorbency properties can alter body temperature, which improves muscle performance and delay exhaustion [2].

Polyester

Polyester has excellent dimensional stability and good resistance to dirt, alkalies, mold, decay, and organic solvents. good thermal stability is also a quality of polyester. Due to low moisture absorption, low price and easy-care properties polyester are utilized as base fabrics in sportswear. generally, we know that polyester is hydrophobic, by treating polyester with some chemicals it becomes hydrophilic and it can be used as base layers of active sportswear. As polyester is long-lasting, lightweight, and has elasticity and soft hand. These are exceptionally significant characteristics to buyers for wide assortment outerwear and recreational applications. [3,9,14].

surface modification of polyester can be done by introducing free hydroxyl groups on the surface of the filament, which results in the de-structuring of water and which leads to wetting. The mix of restricting properties-a hydrophobic center and a hydrophilic surface-makes a texture wherein the strands urge dampness to move through the texture along the outer most surface of the fiber while the hydrophobic center doesn't retain dampness [14].

Polypropylene

The use of polypropylene fibers has increased in sportswear though it's market share is too small. polypropylene fibers have low moisture absorbency but good wicking capabilities and vapor permeability. polypropylene offers good insulation when wet, it melts at moderate temperature in home dryers. Transportation of Insensible and liquid perspiration away from the skin without being absorbed makes polypropylene as an ideal fiber for sportswear. Polypropylene is claimed as a good performer in moisture management due to its very good thermal characteristics and hydrophobic nature, keeping the wearer warm in cold climate and cold in warm climate [3,9].

Hollow fibers

Hollow fibers have been introduced in the 1980s, whose cross-section is hollow and is available shapes - circular, trilobal or square. The hollow fibers are strong, have better recovery, bulky, and provides good thermal insulation by trapping air. Hollow polypropylene fibers are lightweight, soft, and offers excellent thermal insulation used in thermal underwear [3]

Thermolite manufactured by DuPont is an ultra-fine hollow-core fiber which is used in the cold conditions. Due to the presence of air in the fiber core, the thermal resistance of the fabric is improved and also convoluted fiber surface and the increase in surface air generated by utilizing a fine fiber improves the wicking capability [3].

Microfibers

Microfibers are ultra-lightweight and fine, making them both comfortable and more functional. Innovation in advanced textile for performance wear has prompted very fine deniers, including high-performance microfibers and ultra-microfibers for a second skin. They can be engineered to be anti-static, anti-stress, UV resistant, high stretch, and thermal-isolating.[3].

Microfibers are finer than silk offers excellent drape, resistance to shrinkage, superabsorbent, and possess strength, are manufactured by producing bi-component process using two different polymers that do not mix. These properties empower them to be used in a wide range of utilization [11].

Polyamide fibers

They have various applications for sports textiles, due to its higher moisture absorption capability than polyester and has good wicking ability but have a lower drying rate. Polyamide fibers are strong fibers with, high flexibility, high abrasion resistance, and elasticity. closely woven polyamide fabrics have very low air permeability and make them an ultra-lightweight material for the outer shell of ski garments and windbreaker jackets. Due to the low vapor permeability of such fabrics mean they are uncomfortable when worn against the skin. High-tech fiber engineering allows polyamide to take different looks, handling, qualities and performance properties, such as rapid wicking of perspiration. Polyamides are treated through air texturing to give them a soft handle &natural look, rapid drying can result in easy-care garments. A blend of polyamide with elastane can result in a fabric with a comfortable and in a blend with Teflon one, that is water repellent and stain resistant [3]

Aramid fiber

Aramid is a particular type of polyamide that is very strong and capable of withstanding extremely low temperatures. Aramid microfilaments are developed where research has produced very strong and lightweight aramid microfibers that are used their protective and performance capabilities. Chlorofiber is a generic name indicating that more than 50 percent of the textile's make up PVC. The color fiber content helps the textile to retain its structure. These fibers are generally blended with other yarns such as cotton, silk, wool, acrylic to produce a functional textile. These color fiber-based fabrics have significant advantages for those who take part in highly active and energetic sports like mountain climbing [3].

special fibers for sportswear

Hygra 20

Hygra was launched by Unitika Limited, which is a filament yarn manufactured by using hydrophilic polymer and nylon and it is of sheath-core type. this hydrophilic polymer has an ideal feature, due to its ideal network structure this fiber absorbs water which is 35 times more than its weight and it also has rapid releasing property that the other hydrophilic polymers do not have. This fiber also exhibits antistatic properties even at low wet conditions. Apparel made from this fiber has various applications which also includes sportswear like golf wear, athletic wear, skiwear, etc [9].

Killat N23

Killat N23 is of nylon hollow filaments introduced by Kanebo. This fiber has good hydrophilic character and has warmth retentive property which is due to the presence of a 33% hollow portion in the cross-section of the filament. This is bicomponent and spun filament yarn with soluble polyester copolymer which is a core portion and nylon as a skin portion [9].

Lycra25

Lycra25 is a completely man-made fiber that is of long-chain polymer and it is composed of at least 85% of segmented polyurethane. This fiber has various applications like active sportswear, floor gymnastics, swimwear due to it's fit and comfort properties. In applications like swimwear and gymnastics properties like stretch and recovery are necessary and which is obtained by adding Lycra to the fabric [9].

Dacron

4-Channel Polyester general term for high-performance four-channel fiber produced to move moisture and speed the evaporation of perspiration. This kind of fabric has low drying time, high wicking action, high moisture absorption and transport properties [9].

Yarns for sportswear

Fabrics produced with staple-fiber are more absorbent than the fabrics made of filament yarns of the same content and yarn size, due to the looser packing of the yarn. Loose packing of the yarn increases the fiber surface area for absorption and increasing the gaps between the yarns, increases moisture vapor permeability. Staple fiber yarns have good thermal insulation due to the increased volume of air contained in the yarn. They may also improve the sensorial comfort from a warmer feeling to the touch; the yarns have slightly lower areas of contact to the skin.

Crimping of man-made yarns can improve their water vapor permeability by increasing the bulkiness of the fibers in yarns and yarns in fabrics, thus improving their thermal comfort. However, staple fiber yarns do not shed soil as well as filament yarns and they have a higher tendency to pill or shed lint. Filament yarns are used in the shell and lining of skiwear and in windbreaker jackets where a combination of weave low surface coefficient of friction and dense are desirable [3].

Different fabric structures

Mostly Knitted fabrics are preferred for sportswear, as it has high elasticity and stretchability when compared to woven fabrics, which provide unrestricted freedom of movement and transmission of body vapors to the

next layer in the garment [2]. For warmth and comfort in adverse conditions, textile fabrics may be brushed, padded, bonded, wadded or quilted to give ultra-lightweight volume with little excess bulk. The fabric structure is a vital factor in the structure of sportswear garments. The study on the effect of warp-knitted structure on thermal comfort properties showed that most open construction 3D Eyelet gives the good moisture vapor permeability, but low thermal insulation. Micromesh structure which has small openings or holes over 3D Eyelet, but relatively more open than the Mock Rib and Pique structures, resulted in the most favorable combination of comfort properties.

Dense pile fabrics play a big role in sports clothing and cloths with a high pile traps air for insulation and are very absorbent. Brushed surfaces are often applied as an inner lining where the wearer feels comfortable, as the brushed surface against the skin does not cling to the skin surface. The padding of fabrics is mainly for insulation. Polyester wadding or synthetic foam is sandwiched between fabrics. Some wadding is made from synthetic microfibers making it waterproof and breathable. Knitted fabrics with foam backing can be very soft, and when blended with elastane have good stretch and recovery characteristics, making them suitable for highly active sports.

knitted fabrics that are moisture-wicking tend to be more open in the structure on the back than on the face. In such open structures, moisture from perspiration passes more quickly through. Examples of this include Aertex, a traditional sports fabric that is widely used.

Multi-layer fabrics, manufactured by warp and weft knitting process, became common for active sportswear. The action of layered fabrics in thermophysiological regulation is much better than single layer fabrics. Each layer has various functions to be performed; the layer next to the skin must wick away the perspiration rapidly to the outmost layer, which absorbs and disperses it quickly to the environment by evaporation. In doing so, it takes away the body temperature and keeps the body cool. On the inside, a man-made material with excellent moisture transfer properties and better capillary action e.g. polyester, acrylic, nylon or polypropylene is used, whereas on the outside, a material which is an excellent absorber of moisture, e.g. wool, cotton, viscose rayon or other blends can be used [3].

Finishes for sportswear

To make the fabric water repellent and flexible it is applied with silicone finish. which can be used either on the fiber or the fabric. When silicone is used in concentrated form, coatings are abrasion resistant and water repellent and very useful for outdoor activities. A very fine coating creates a fabric that can be washed or dry cleaned and the coating is often permanent. Fabrics with a silicone finish tend to keep their shape after repeated washing; they are also non-shrink as well as being crease-resistant. Moisture management treatment assists like quick-wicking and evaporation and provides high-value addition to casual wear and sportswear will enhance the comfort level of the wearer. to increase moisture absorbency several moisture management finishes are used; the fabric is durable to home laundering and improves wicking and wetting action [3].

Microencapsulation technology has developed fabrics with a wide variety of "health-giving" and "well being" substances contained bubbles suspended along their fibers. As the textile creases when worn the bubbles break and gradually release their contents onto the skin of the wearer. These fibers are now being used for sports clothes

Phase Change Materials (PCM) are developed for active-sportswear. These materials contain a chemical that changes from liquid to gel and maintains body temperature. This changes the fabric's insulation properties so that clothes can be designed that maintains the body at a constant temperature. Phase change technology uses materials that respond to both body and environmental temperatures, for example, paraffin wax. This can be added in the form of a microthermal membrane, using by microencapsulating technology, contains the PCM with an acrylic shell. Alternatively, a garment lining can be given a PCM film with a plastic coating. Heat energy is stored by PCM, as the temperature drops, the materials become solid, and gradually release the stored heat.
[3,2].
Shape memory polymers materials are those which is capable of remembering and retaining its shape or return to a previous shape. A fabric made up of shape memory polymers can sense changes in the outside environment and can estimate intelligently and control its response to ensure the maximum level of comfort. This polymer is also different as the temperature at which micro-Brownian motion begins can be freely specified. This means that the activation point can be set to match the environmental conditions in which a garment is to be used [2].

Moisture Management properties

During the various activity, the wearer sweats and the cloth worn next to the body will become wet. The leisure wears and sportswear creates a barrier for proper transfer of excess heat increasing core temperature and skin temperature (<37^{0}c) which increases perspiration. As the heat increases fabric becomes moisture and which reduction in body heat and fatigue may set in amongst wearer. So the fabric worn next to the skin should have two properties. i) fabric should evaporate the perspiration from the skin. ii)moisture should be transferred into the atmosphere and make the wearer comfortable. Moisture management indicates the transport of both moisture vapor and as well as liquid away from the body. Moisture management is a co-aspect of a textile's properties that always needs to be regarded in tandem with comfort. Moisture management property is the prerequisite for active sportswear. which can be achieved in many ways such as changing the fibre surface chemistry, usage of modified cross-sectional fibres, fabric engineering, yarn engineering (blending), enzymes or alkalis and fabric chemical treatments with silicones, [12].

Effect of Micro Fibers in Moisture Management

Micro-fibers gives soft feel like cotton. A part of these micro-fibers offers wrinkle resistance, silky feel, drape, lightweight, softness. There are various advantages with micro fifibres over normal fifibres, with a decrease in filament size, the surface area of yarn increases *i. e,* the number of filaments in a yarn result in more surface area. Roundness and bulk of the yarns combined with their remarkable regularity ensure the production of knitwear with a smooth fluid appearance, comfortable, light and very soft.

Microfiber shows excellent moisture transport property and ensures better moisture control than the other construction parameters of comparative fineness greater than 1.0 denier in the microclimate near the skin. Microfibers have excellent breathability and moisture transport properties and because they are air and waterproof, these fabrics are widely used in active sportswear.

In a textile structure, the gaps between fibers will form capillaries. The closer the fibers in yarns the smaller the apparent diameter and the more rapidly wicking can occur. Fiber properties like cross-section, diameter, stiffness, and crimp play an important role in capillary formation [12].

Moisture Management Using Finishing Processes

the single blend of fibers cannot give ideal sportswear. The correct type of fibre should be in the correct place. The wicking ability of the fabric is mostly depending on its base fibres moisture properties. Capillary action is mainly determined by its basic property. The surface energy in a textile material is determined largely by the chemical structure of the fiber. Hydrophilic fibers have high surface energy they pick up moisture faster than hydrophobic fibers. Hydrophobic fifibers has low surface energy and repel moisture. Special fifinishing processes are used to increase the difference in surface energy between the face and back of the fabric to increase its ability to wick.

Moisture transportation process in textile materials is carried out in three steps viz. wicking, absorption, and evaporation if the material is hydrophilic, and in case of hydrophobic materials wicking, spreading and evaporation takes place. The rate of evaporation and the rate of wicking are the key factors in moisture management. for better performance fabrics Higher the rate of wicking and evaporation will be observed. Moisture transport property of a fabric is affected by various factors such as chemical treatments like plasma, enzymatic treatment, alkaline hydrolysis and types of hydrophilic finishes and silicone finishing [12].

Densely woven water breathable fabrics

The closely woven waterproof breathable fabrics consist of cotton or man-made microfilament yarns with compacted weave structure. VENTILE is one of the famous waterproof-breathable fabrics manufactured by using long-staple cotton with a minimum of spaces between the fibers is 1. Usually combed yarns are weaved parallel to one another with no pores for water to penetrate. Usually, oxford weave is used. When cotton fiber comes into contact with water it swells and which reduces the size of pores and this kind of fabric requires high pressure to cause penetration. hence waterproofing nature of the fabric is obtained without application of any finishes. closely woven fabrics can also be produced from micro-denier filament yarns. The individual filaments in these yarns are of less than 10 microns in diameter so that fabrics with very fine pores can be manufactured [14].

Laminated waterproof breathable fabrics

Laminated waterproof breathable fabrics are produced for the end-use of membranes into the textile product. These are thin membrane made of polymeric materials. which has high resistance to water penetration but

allows water vapor at the same time. The maximum thickness of the membrane is 10 micron. They are of two types:

1) Microporous membranes

2) Hydrophilic membranes.

The microporous membranes consist of fine holes on their surface smaller than raindrops but larger than water vapor molecule. Some of the membranes made of Polytetrafluoroethylene PTFE polymer, Polyvinylidene fluoride PVDF, etc.

The hydrophilic membranes are thin films made of chemically modified polyester or polyurethane. These polymers are modified by the incorporation of poly. The poly (ethylene oxide)4 consists of the hydrophilic part of the membrane by forming an amorphous region in the main polymer system. This amorphous region acts as intermolecular pores allowing water vapor molecules to pass through it but preventing the penetration of liquid water due to the solid nature of the membrane [14].

Moisture Transport Mechanism

The mechanism by which moisture is transported in textiles is similar to the wicking of a liquid in capillaries. Capillary action is determined by two properties:

• Diameter

• The surface energy of its inside face.

surface energy increases with a decrease in diameter, a capillary increase of liquid is due to the more prominent the inclination. In textiles, the spaces between the fibers form capillaries. The wicking ability of fabric increases with a decrease in spaces between the fibers. Fabric constructions, which effectively form narrow capillaries, pick up moisture easily. Such constructions include fabrics made from microfibers, which are packed closely together. However, capillary action ceases when all parts of a garment are equally wet. The surface energy in a textile material is determined by Hydrophilic fibers to have high surface energy. Consequently, they pick up moisture more promptly than hydrophobic fibers and Hydrophobic fibers, by contrast, have low surface energy and repel moisture [14].

Factors Affecting Moisture Transport

There are many factors, which affect moisture transport in a fabric. few of them are listed below:

•Type of fiber,

• the weave of the fabric,

• Weight or thickness of the material; and

• Presence of chemical treatments.

Man-made fibers can be either hydrophilic or hydrophobic. They also have a wide range of bulk absorbencies, usually reported by suppliers and testing organizations as the percentage moisture regain by weight. Synthetic fabrics are generally considered to be the best choice for garments worn as a base layer. This is because they can provide the best combination of moisture management, softness and insulation properties.

While most fabrics, both natural and man-made, can wick moisture away from the skin, not all of them are fast-drying and air permeable-two factors, which have a direct impact on cooling and perceived comfort. High-tech synthetic fabrics are lightweight, are capable of transporting moisture efficiently, and dry relatively quickly.

It is generally agreed that fabrics with moisture-wicking properties can regulate body temperature, delay exhaustion and improve muscle performance. While natural fibers such as cotton may be suitable for the clothing worn for low levels of activity, synthetic fabrics produced from nylon or polyester are better suited for high levels of activity. They absorb less amount of water than cotton, but can still wick moisture rapidly through the fabric [14].

Evaluation Methods of Comfort Properties of Sportswear

Wear comfort can be examined by two methods i) subjective method ii) objective method. Subjective evaluation is carried out by the Wear trial technique it is the most common method. In this method assessment is done by asking players to wear the garments and players give rating by using the garments during exercise, the rating is given based on the comfort properties like clingy, clammy, damp, sticky, heavy, etc. The clothing comfort of sportswear is mainly based on moisture comfort sensory. heat transmission and Moisture vapor transmission through fabric can be tested by heat flux sensing principle using various devices like the sweating guarded hot plate and Permetest, which sense the sweating skin and determines the moisture vapor resistance of fabric by measuring the evaporative heat loss in the normal conditions. combined heat and moisture transfer are tested by using Thermal manikin There are 2 kinds of manikin available which are dry manikin and sweating manikin. The dry manikin is used to know dry heat flow, sweating manikin senses the perspiring human body. By using heaters within trunk core temperature is maintained at 37ºC. By using permeable waterproof fabric skin is manufactured, which is similar to human skin by filling it with water. Independently-controlled thermal zones can be created at various zones of sweating manikin to measure the moisture transmission and heat from various parts of the human body. By using contact angle Wettability of a material can be known. After wetting wicking action is carried out in which water is moved along the capillary formed in between the fabric. Wicking is tested in two methods i) infinite reservoir ii) from the finite reservoir. The in-plane wicking, longitudinal wicking, and transverse wicking are different forms of wicking from the infinite reservoir, but spot test is another mode of wicking from the finite reservoir. By using a porous plate which works on a gravimetric principle developed by D'Silva In-plain wicking and absorption is measured at a time. Liquid moisture transmission characteristics in various directions are tested by using moisture management tester and by using electrical resistance technique liquid transfer from one face to another face of the fabric is tested. Skin sensorial comfort depends on the friction between surface roughness and fabric skin. The most common method of testing system Kawabata Evaluation System of fabric handle (KES-F system). In both subjective and objective methods Ergonomic comfort of sportswear can be evaluated by measuring the wearing pressure and other related sensations. By using clothing pressure and rotating level of joint movements Motion performance of sportswear can be measured. effect of sportswear is also known by another method like video-based motion analysis [10]

Applications of Sportswear Fabrics

Sports textile has many applications. Some of them are given below [2]:

1. Sports composites
2. Artificial turf
3. Ballooning fabrics
4. Parachute fabrics
5. Sailcloth.
6. Sports nets
7. Sports footwear.
8. Tents for sports.
9. Swimming costume.
10. Sleeping bag.
11. Sports equipment.
12. Cycling.
13. Golf.
14. Tennis.
15. Mountaineering.
16. Skiing.
17. Cricket, etc.

Conclusion

Recently, people consider sport as a vital exercise in their day to day lifestyle to keep themselves physically fit and mentally strong. Among various applications of textiles, sports textiles are important due to the change in athlete preferences. A well-designed sports textile must meet the Thermo-physiological, tactile, mobile, psychological comfort. All these can be achieved by excellent thermal insulation and good moisture management properties, air permeability.

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