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## Review Articles

# High active sportswear – A critical review

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The fabrics used for active sportswear are specially constructed in terms of the geometry, packing density and structure of the constituent fibres in yarn as well as their construction in order to achieve the necessary dissipation of heat and moisture. Performance of player can be enhanced by specialised sportswear like compression athletic wear and other innovative products like biomimetic swimwear. Specialised products are continuously being innovated where usually performance, quality, design and not the price seem to be determining factor. This paper reports the functional requirement of high active sportswear, various aspects of sportswear comfort, their evaluation methods, effects of fibre parameters like shape and geometry, yarn constructional parameters, fabric structural parameters, finishes, performance enhancement and innovative material for sportswear.

**Keywords**: Evaluation methods, High active sportswear, Innovative products, Wear comfort

## 1 Introduction

There has been enormous market growth for sportswear over last 20 years. Global sportswear market including performance sportswear, sportswear inspired fashion clothing and footwear grew by 7.5% with market of $244 bn as reported in Eurometer International (2013). The global wholesale market share for sportswear clothing is worth $41.5bn (2009) and its target is to reach $126.3bn by 2016 as per the report published by GIA[1]. As per the market demand, sportswear can be categorized into four groups, viz performance sportswear, basic sportswear, sports leisurewear and sports- fashion clothing. Performance sportswear is highly technical-oriented clothing which enhances the performance with special functionality. It is produced in lowest volume and highest price range, whereas basic sportswear is cheaper and more stylish while retaining as many of the material attributes as possible. Sports leisurewear is replica of performance sportswear, worn at home and is sold in higher volume at much smaller price[2]. Functional requirement of performance sportswear depends on the nature of sport, climatic conditions and amount of physical activity[3]. High active sports are classified as one which is being played for short duration of time with maximum physical activity like tennis, soccer, running, jumping, etc. Wear comfort of high active sportswear may affect the performance of player and hence it becomes one of the most important quality criterion. The objective of this paper is to review the past research work carried out in the area of wear comfort and performance enhancement by high active sportswear.

## 2 Functional Requirements of High Active Sportswear

In high active sports like tennis and soccer, heat stress is of great concern due to high level of metabolic heat generation which is in the range of 800 -1300W. This amount of heat can increase the body core temperature by 1.5 – 2ºC. To control the core temperature of body, sweat generation takes place and heat of vaporization of water is used to give the cooling effect[4]. Sweat generation can go as high as 2.5L/h and hence the main functional requirement of high active sportswear is sweat absorbing, fast drying and cooling[5].

High active sportswear should also have high stretch and elastic recovery to provide sufficient fit and freedom of movement to the wearer. In number of active sports like jumping, running and power lifting, compression is created by stretchable fabric to enhance the performance of an athlete. Compression athletic wear (CAW) provides the necessary compression and anatomic fit to an athlete. They are also known as “skin suits” as they conform to the

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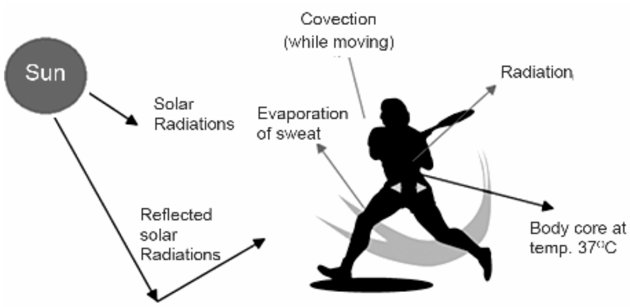


Fig.1 — Modes of heat transfer in active sports

natural curves of the body acting as second skin[6]. Other requirements laid down for active sportswear are smoothness, softness, UV resistance, light weight, and easy care[7].

## 3 Comfort Properties of High Active Sportswear

Wear comfort of active sportswear can be divided into four different main aspects, namely thermo-physiological comfort, skin sensorial comfort, ergonomics wear comfort and psychological comfort.

Human body tries to maintain the core temperature at 37±1ºC. There are four modes of heat transfer to maintain the thermoregulation of human body, viz conduction, convection, radiation and evaporation[8]. During active sports, 80% of energy is converted into heat and in warmer areas when air temp is higher than body temp., convection adds to heat loads (Fig.1). In these conditions, evaporation remains the only mode for heat loss. The evaporative requirement to maintain the body core temperature is determined by the sum of the metabolic heat production and the radiative and convective heat exchanges. Amount of heat loss depends on the rate of sweat evaporation which further depends on the evaporative capacity of environment. For these active sports, sweat rate can go up to as high as 2.5 L/h in hot and humid conditions due to additional convective and radiative heat loads[9]. Regional distribution of sweat takes place on human body. It has been reported that back area sweat is substantially higher than chest area of players[10].

Thermo-physiological comfort determines the breathability and moisture management. It comprises heat and moisture transport through the fabric, whereas moisture can be in the form of vapour and liquid. Clothing provides a microclimate (Fig.2) between the body and the external environment and acts as a barrier for heat and vapour transfer between the skin and the environment[11]. There are three main

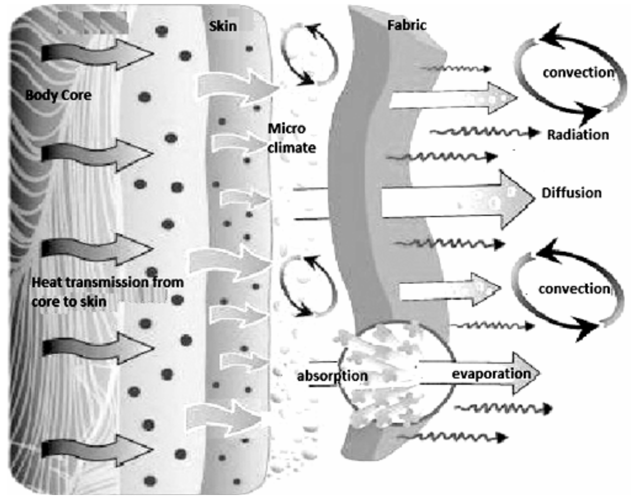


Fig.2 — Heat and moisture vapour transmission through textile material

processes involved in moisture transmission through fabric[12], namely diffusion of moisture due to moisture vapour gradient across fabric[13], sorption-desorption by hydrophilic sites on the fabric[14] and forced convection by moving air close to skin[15]. In severe sweating conditions, fabric next to the skin should not only absorb liquid rapidly but also transport it through the fabric promptly to avoid the discomfort of the fabric sticking to the skin. Liquid moisture transportation through textiles takes place in two sequential processes; wetting followed by wicking[16]. Wetting is the initial process involved in fluid spreading. The fibre-liquid interface replaces fibre-air interface in wetting. Wicking is due to fibre-liquid molecular attraction at the surface of the fibre materials, which is determined by the surface tension and the effective capillary pathways and pore distribution[17]. Skin temperature and moisture content of microclimate are strongly stimulated by the level of physical effort. The fabric type has a significant effect on moisture of skin[18]. A study showed that moisture vapour resistance and moisture accumulation within clothing determines the comfort of sportswear during sports[19]. Clothing thermal insulation decreases during perspiration, and the amount of reduction varies from 2% to 8%, due to accumulation of water within clothing, which can cause the "after chill" effect to wearers after heavy exercise[20].

Skin sensorial or tactile comfort of sportswear is determined by surface friction, roughness and softness[5]. Skin is the largest organ of human body and is more prone to injury in sports. Chafing is the most common problem in active sports which occurs due to mechanical rubbing of the skin with clothing or other parts of skin. Skin abrasion is another skin injury which is removal of skin cells during rubbing with external surfaces like synthetic turf[21]. Other skin problem like Urticaria and hives are also reported due to repeated rubbing between skin and ill-fitting apparel[22]. It has been reported that these types of injuries can be reduced by selecting well-fitted and low friction sportswear[21,23].

Ergonomic comfort determines the fit and freedom of movement which depends upon the fit design, fabric elasticity and pattern construction[24]. In active sports like running, skin extension and contraction take place due to high degree of body movement which alters the corresponding body measurements. Sportswear clothing should not restrain these movements else discomfort will be created due to undesired garment pressure on body[25]. Elastic fabric is commonly used in tight-fit running shorts which provide the desired shape and size with adequate room for body movements[26].

### 3.1 Evaluation Methods of Comfort Properties of Sportswear

Wear comfort can be evaluated by both subjective and objective methods. Wear trial technique is mostly used in subjective assessment. In this technique, subjects (players) are asked to wear garments under study. During exercise, each subject has to rate the sportswear on selected comfort sensation like clammy, clingy, sticky, damp, heavy etc. It has been reported that moisture comfort sensory perception is the largest contributing factor of overall clothing comfort of sportswear[27].

There are numerous objective methods present in literature to measure various thermo-physiological comfort properties. Moisture vapour transmission and heat transmission through fabric can be determined by heat flux sensing principle using permetest[28] and the sweating guarded hot plate[29], which simulates the sweating skin and determines the moisture vapour resistance of fabric by measuring the evaporative heat loss in the steady state conditions. Thermal manikin is the new innovative method which is used to evaluate combined heat and moisture transfer. There are two types of manikin available, viz dry manikin and sweating manikin. First one is used to measure dry heat flow[30], whereas sweating manikin simulates the perspiring human body. The core temperature is controlled at 37ºC by using heaters within trunk. The skin is made up of strong permeable waterproof fabric which is filled with water to create soft body similar to human skin[20]. Independently-controlled thermal zones can be created at different locations of sweating manikin to measure the heat and moisture transmission from different parts of human body[31].

Wettability of material can be determined by measuring the contact angle. Image processing principle was used in many techniques like drop analyser tester and automated contact angle tester[32]. Wicking is the next process after wetting in which liquid moves along the capillary formed within the fabric. Wicking can be evaluated either from infinite reservoir or from finite reservoir[16]. The longitudinal wicking, in-plane wicking and transverse wicking are various forms of wicking from infinite reservoir, whereas spot test is another form of wicking from finite reservoir[33]. Absorption as well as in-plane wicking have been simultaneously measured using a porous plate by a test method developed by D'Silva[34] based on gravimetric principle. Moisture management tester evaluates the liquid moisture transmission characteristics in various directions of fabric as well as liquid transfer from one face to another face of fabric by using electrical resistance technique[35].

Skin sensorial comfort depends on friction between fabric skin and surface roughness[36]. The most common evaluation system is four modules of Kawabata Evaluation System of fabric handle[37] (KES-F system) In active sports, presence of moisture can change the perception of roughness[38] and hence an evaluation system to measure the surface properties of sportswear under wet conditions has been suggested and it is reported that the occurrence of moisture increases the friction and fabric clinging, resulting in unpleasant sensation[39].

Ergonomic comfort of sportswear can be evaluated by measuring the wearing pressure and other related sensations by both subjective and objective methods[40]. Motion performance of sportswear can be analysed by clothing pressure and rotating level of joint movements[41]. In another method, video-based motion analysis was used to evaluate the effect of sportswear on body motions[42].

### 3.2 Effect of Various Parameters on Comfort of Sportswear

#### *3.2.1 Type and Geometry of Fibre*

Synthetic sportswear shows better performance with significant improvement in the mean skin temperature and comfort sensation rating during exercise[43] as well as faster recovery with better sweating/shivering sensation after exercise as compared to cotton[44]. Fibre cross-sectional shape plays an important role in liquid moisture transmission properties of fabric. The most commonly used synthetic fibre for active sportswear is polyester. Liquid moisture transportation is reported to be higher in that commercial sportswear which is knitted with profiled polyester having higher filament shape factor[45]. Tetrachannel and hexachannel cross sections offer more surface area for liquid to transport and gives better wicking ability and faster drying[46]. Polyester with trilobal and triangular cross-sections is also reported to improve liquid moisture transmission as compared to normal polyester with circular cross-section. Filaments with higher shape factor have better wicking rate due to their higher specific surface area[47]. Five-leaf cross-sectional shape[48] showed enhanced wicking ability of fabric as compared to circular fibre due to higher capillary forces generated by larger specific surface area. Overall moisture management is reported to be improved with filament shape factor, however the fabric becomes less permeable to air and moisture vapours[49].

Knitted fabrics made by using microfibre polyester show excellent moisture-related comfort properties like absorption, wicking and rate of drying. Small size of capillary in micro denier yarn increases the capillary pressure which drives the water transfer in to the capillaries and results in higher wicking[50].

Fabric, with quick absorption and fast releasing of moisture, can be made by addition of small amount of hydrophilic fibres with polyester (PET). It gives surprising level of wearer comfort and wearer performance but the amount of fibres is very crucial to the moisture management and drying capability. It was reported that 10% and 15% cotton blends are more comfortable than 5% and 20% cotton blends. PC (polyester/cotton) blends reduce texture roughness compared to 100% PET[51]. Combinations of PET with thermo-regulating viscose Outlast gives better wicking ability but poor drying capability[46].

In comparison to PC spun yarn, profile polyester filament in core and cover of PC composite spun yarn showed better absorption capacity due to hydrophilicity of cotton and better diffusion rate due to higher siphoning capacity of PET filaments[52].

Fabric with splitting nylon/polyester (N/P) microfibres makes closely packed and aligned fine capillary columns of water between the fibres, resulting in excellent absorbency. Split-type microfibres were produced by splitting bi-component conjugate filaments such as nylon/polyester by exposure to alkaline solution with thermal and chemical treatments. The micropores increase by forming dense and even splits and hence can absorb much liquid at high speed. However, with excessive alkali hydrolysis, there is an adverse effect on water absorption properties[53].

It has been reported that soyabean cotton blended T-shirt had superior wicking than cotton T-shirts, when the body began to sweat, the sweat on skin surface wetted the fabric and then evaporated soon to the outer environment thus helping the players to feel much thermal comfort[54]. Air permeability and water vapour permeability are found to decrease with the decrease in fibre diameter and increase in fibre cross-sectional shape factor[47].

Elastane is widely used in sportswear for its superior stretch and recovery properties. Dynamic elastic recovery (DER) can assess the instantaneous garment response due to body movement; the elastane bare plaited fabric is found to have higher DER than fabric knitted from spandex core-spun[55]. Elastic recovery and pressure drop of compression athletic wear has been studied using artificial leg prototype and it is reported that in plated construction, with coarse elastane and modified polyester cross sectional shape, recovery characteristics are improved with consistent pressure over time[56]; however inferior thermo physiological comfort was reported with increase in elastane linear density[49]. In compression sportswear made of core-spun elastane yarn, wicking and moisture management are reported to be better for the fabric with lower elastane content and elastane stretch[57].

#### *3.2.2 Yarn Parameters*

Yarn twist and yarn linear density are influencing factors in moisture transmission. Moisture management properties, tested on moisture management tester (MMT), like absorption rate, spreading speed and maximum wet area circle radius are reported to decrease with higher wetting time of fabric at higher twist coefficient and linear density of cotton yarns[58]. It has been reported that with the increase in twist coefficient, permeability to air and water vapour is improved and wicking height and absorption are reduced[57].

High degree of filament drawing as in parallel drawn yarn can reduce the wicking height; however the wicking height is reported to initially ascend until the maximum height is reached and then descend with the increase in twist for filament yarn[48].

Fabric knitted with microdenier polyester yarn is reported to have better moisture vapour transmission, faster heat transfer and cooler feeling at initial touch as compared to spun polyester, PC and 100% cotton. It has been further reported that moisture management finish significantly increases the thermal conductivity, thermal absorptivity and water vapour permeability[59].

***3.2.3 Fabric Structure***

*Single Knit Structures*

Single jersey (SJ) fabric reported to have better wickability and higher absorption as compared to knitted structures having knit tuck combination like pique and honeycomb. The SJ structure consists of knit loops only, so loop leg orientation is only towards wale direction, which helps for better wicking in comparison to other structures consisting of combination of knit-and-tuck loops[60].

Comfort characteristics of knitted fabric are found to be significantly affected by its structural parameters like thickness, porosity, pore size, density, tightness factor and stiffness. Slack fabric have higher transfer wicking ratio while lower contact angle as compared to loose fabric for different knitted structures. Water evaporation rate is found to be higher for thin fabric[61]. A thin and porous knit structure is reported to have optimum moisture vapour dissipation properties. The fibre, yarn and fabric characteristics which determine the fabric thickness and permeability significantly affect the moisture vapour transmission and microclimate drying time[62].

Cover factor is reported as a key structural attribute influencing the moisture management capacity of the knitted fabric. Fabric knitted with higher cover factor takes more time to wet and liquid moisture spreads in to the smaller radius, resulting in lower overall moisture management capacity[63].

*Two Layer Knitted Fabric*

Two layer knitted fabric structure is very popular for sportswear fabrics. Inner and outer layer of these fabrics are completely separate and unique with distinct functionality. Liquid water transfer from inner to outer layer depends on hydrophillicity of both layers and to great extent on their difference. More water can be transferred from inner to outer layer if inner layer shows poor water absorption while outer layer shows higher water absorption. The inner layer made of hydrophobic filament and outer layer made of hydrophilic fibre is preferred in two layer fabric[64].

Fabric knitted with polypropylene (PP) filament on the inner side and facing the skin is reported to have better wicking, water holding capacity and moisture vapour transmission when combined with viscose and cotton on the outer side of fabric[65]. Two layer fabric with polypropylene on the inner side and cotton on the outer side is reported to have good overall moisture management capacity due to quick transfer of liquid from inner to outer side[66].

Two layer fabric made using 30% TENCEL® and 70% polyester in the outer layer gives better moisture absorption and buffering, equal moisture spreading, same drying rate, equal wet cling behaviour, a much better balance of water vapour permeability, thermal comfort and a less synthetic look and touch as compared to 100% polyester[67].

Plated fabric made from polyester and tencel showed the most favourable effect on the energy cost with better efficiency and endurance of the wearer as compared to 100% tencel and 100% polyester[18]. Wool has low surface energy so when it is used as inner layer with cotton as outer layer it shows good moisture management properties and transfers liquid sweat giving much dry feeling on the inner side[68].

Liquid moisture management properties of wool/PET and wool/bamboo plated fabrics have been investigated on MMT[69]. It was found that plated fabric with wool knitted on technical back of all fabrics shows lower top wetting time, higher value of top spreading speed and better overall moisture management capacity as compared to 100% wool and 100% bamboo fabric.

In winter sports wear, fabric with wool in inner layer and polyester in the outer layer was studied and it was reported that the loose construction of each layer in fabric assembly diffuses higher liquid moisture as compared to their tight counterparts[70]. During subjective wear trial, two layer polyester cotton fabric showed poor performance in dampness and comfort rating as compared to 100% polyester and Coolmax® interlock knitted structure[71].

The plain plated fabric with cotton and bamboo in outer layer and Coolmax® in the inner layer showed good water absorption, whereas fabric knitted with PP thread and cotton yarn combination showed worst ability to absorb water. The plain plated weft knitted structure reported to have better dryness sensation as compared to two layer combined structure knitted with the same yarns[72].

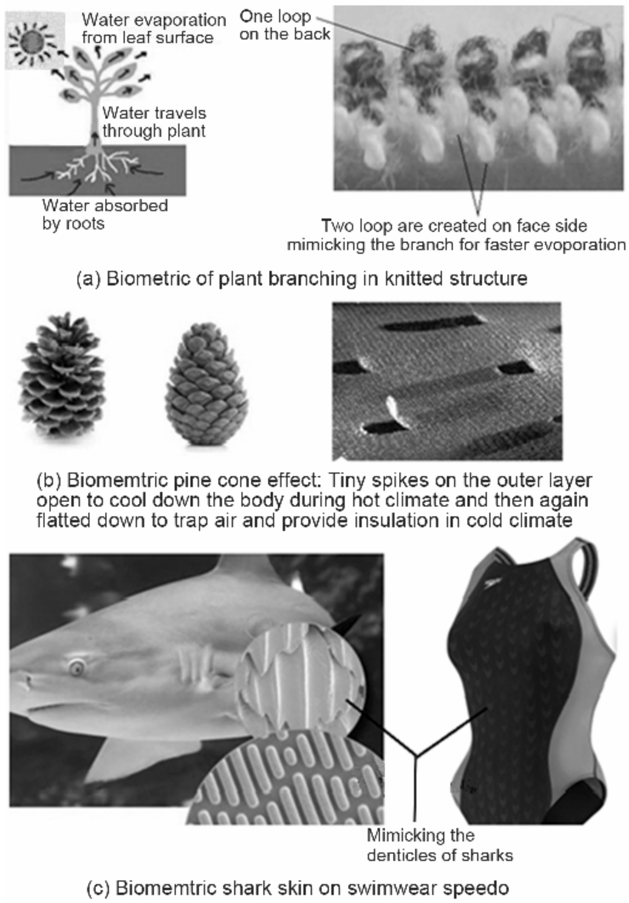


Fig.3 — Biomimetic sportswear

*Biomimetic Structure*

Biomimetics refers to replicating or mimicking the mechanism found in nature. Few attempts to biomimetic fluid flow have been made in various application areas in past[73]. Biomimetics of plant structure in knitted fabric can improve the water absorption and one way transport property of the fabric and can be very well exploited in sportswear application[74]. In this structure, larger loops are formed at the back side and smaller loops are formed at the face side (Fig.3), so that the loop density at the back is lower, which results in higher inter yarn space at the back and smaller inter yarn space at the face, mimicking the taper of water conduits in trees.

Loops in back side are formed by two yarns bundled together on every other needle of weft knitting machine which promotes liquid transport from back to the face, creating a process similar to 'cohesion-tension' mechanism in plants. These fabrics possess a significantly greater initial water absorption rate, one way transport capacity and air permeability[75]; however, their water vapour permeability is found to be less than that of control fabric due to increased fabric thickness[77].

Biomimetic warp knitted fabric with branching structure has been developed using two guide bars with polyester and nylon[77]. In this structure, less number of longer loops in the inner side than that in the outer side builds branching structure, which pumps water upwards from the inner to outer side and facilitates water transport properties. This fabric showed significantly faster initial water absorption rate, improved water spreading speed and lower air resistance than conventional control fabric with same material and construction.

Another example of biomimetic clothing is inspired from pine cone. This fabric has many tiny spikes on the outer layer which would open to cool down the body during hot climate and then again flatted down to trap air and provide insulation in cold climate[78].

#### *3.2.3 Finishing Treatment*

Functional sportswear was developed by graft polymerization process in which hydrophobic inner side and hydrophilic outer side of fabric was created by polymerisation of acrylic acid on polyester fibre. High performance of moisture and odour control with effective dispersion of sweat was reported for this fabric[79]. In another attempt, polyester fabric with incorporated activated carbon has been developed which shows improved moisture comfort due to absorption of sweat impulses by carbon particles[80]. This type of sportswear is found to be more comfortable in mild physical activity but not in high strenuous exercise due to slower drying[81]. Moisture management finishes enhance the comfort level in sportswear by rapid wicking and evaporation. MMF Resil HJHP increases the absorbency in polyester when used alone and gives better wicking when used with other finishes like Resil Nanocelle G6[82]. The nano dry finish for Nanotex LLC is also applied to sportswear to improve absorbency of sweat[83]. The presence of either a microporous membrane or a laminating substrate in the double fabric assembly increases the vapour pressure build-up and a prolonged inner fabric surface temperature[84]. Thicker, less porous membrane with smaller pore size increases rate of moisture vapour build-up in microclimate and gives longest peak time of surface temperature.

Sportswear gets easily contaminated by perspiration which leads to bacterial growth. Fragrance finishes like microencapsulated peppermint

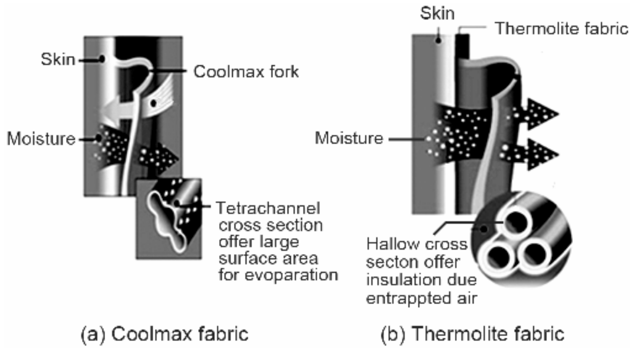


Fig. 4— Innovative fibre material for sportswear

is claimed to have muscle easing properties and antimicrobial finishes like betacyclodextrin kills bacteria[83].

## 4 Performance Enhancement by Sportswear

Heat stress can be reduced by suitable choice of sportswear. Differences in heat stress were reported with different types of sportswear by measuring mean skin temperature change, mean core temperature change, heart rate and total sweat loss[85]. Moisture absorption of sportswear can influence the physiological responses and exercise performance. It was reported that clothing with higher moisture absorption enhances the performance and pitching speed of baseball players[86]. A good correlation between moisture transmission of fabric and athlete's physiological response has been reported. A fabric with better moisture management properties increases athlete's cardio-respiratory fitness and performance[87]. Colour of sportswear can also influence the performance of player. It has been reported that red colour enhances the performance by stimuli of the testosterone dependent signal[88].

The compression athletic wear (CAW) improves the performance of players in number of active sports like jumping, power lifting and running. An athlete showed faster running speed over 10km with lower heart rates and reduced post exercise muscle soreness when wearing CAW as compared to control[89]. Compression garments are reported to cause reduction in metabolic energy cost of running at specific speed and improved sub maximal running economy[90]. It has been reported that compression shorts resist fatigue due to reduced muscle oscillation during landing in sports like sprints or jump events[91]. Enhanced performance by using CAW may be due to improved venous return and cardiac input which would reduce cardiovascular stress on athlete[92]. Another mechanism of improved performance has been proposed which suggested that athletes run at a faster speed due to increased lactate clearance[93] and improved leg power using CAW[94]. Biomematic swimwear is reported to increase the swimmer's speed with reduced net active drag force as compared to normal swimsuit[95].

## 5 Innovative Sportswear Products

Some high performance fibres like Coolmax®, Thermolite and Thermocool (Fig.4) are being offered by Advanced Fibre Technology (ADVANSA) for various sportswear applications[96]. Coolmax® *active* is a high tech fibre made from specially engineered four channelled and six channelled polyester fibre which forms a transport system with an increased surface area that pulls moisture away from the skin to the outer layer of the fabric and keeps the wearer cool and dry[97]. For active sports in cold climate, Thermolite® is very popular. Hollow core fibres trap in air for great insulation and provide warmth and comfort without weight. The large surface area allows the fast evaporation of perspiration and wearer stays dry 50% faster than cotton[98]. Channelled surface has been combined with hollow core in Coolmax® *all season* which move moisture away from the skin when wearer is hot as well as provide warmth for added comfort in colder days[99]. Sportwool® is a unique fabric developed for active sportswear by CSIRO Australia. It is basically a two layer moisture management fabric with wool on the inner side and synthetic fibre on the outer side[100]. Another innovation of CSIRO is Quick dry wool with water resistant finish on wool which dramatically reduces the drying time[101]. Blends of wool and moisture management fibres such as Coolmax and Finecool have been studied to produce innovative yarns with specific functionalities[102]. It was found that fabrics with Coolmax fibres show the best capillary performance with quick transport of the perspiration from skin to environment. Finecool fabrics show higher drying rate with quick drying after wetting. Wool-based fabrics show lower absorption rate but good drying capacity.

Toray offered many moisture management fabrics like Stunner QD® and Field sensor®. Stunner QD® is nylon woven fabric which quickly absorbs, disperses and evaporates perspiration for quick drying. Fieldsensor TM® has brushed inner side which provides insulation and moisture management, thus making it suitable for winter active sportswear. Fieldsensor R® is ecofriendly moisture management fabric made from recycled polyester fibres which quickly absorb perspiration, carry it rapidly to fabric outer surface and disperse throughout outer surface for rapid evaporation[103].

Fabric Coating with micro-encapsulated phase changing material has been exploited by Outlast[104]. Products with Outlast technology buffer changes in humidity and temprature in microclimate and external environment. They maintain constant body temprature by absorbing excess body heat when temprature starts rising due to heat production and releasing it when temprature falls during cooling[105].

Inotek® fibre is innovative biomimetic . When it absorbs moisture, it shrinks to thin sturcture causing microscopic air pockets to open and increase the breathability. This response is reversible and fibres come back to original dimension in dry conditions[106].Skin® 400 series is elastane incorporated warp knitted innovative compression athletic wear which can increase the oxygen delivery to active muscles by dynamic gradient compression[107]. Biomimetic swimsuit Fastskin developed by Speedo® (Fig.4) is inspired from shark skin. The denticles of shark's skin and super stretch property of fabric can enhance the performance of swimmer by shape retention, muscle compression and reduced drag coefficient[95].

## 6 Conclusion

High active sportswear is very vast and challenging field in which required functionality can be designed by suitable choice of raw material, structure and geometry of fibres, yarns and fabrics, surface modification and garment assembly technique. Moisture management properties like sweat absorption, sweat dissipation and faster drying are primary desirable functions of high active sportswear which affect the comfort sensation of player during the game. A number of products have been developed in the past to maximise the comfort. Performance has also been enhanced by incorporating special functionality like compression and reduced drag force in textile assemblies, however, there was no mention of the comfort aspects of this performance enhancing sportswear. Therefore, a fresh approach is required which should aim to develop performance enhancing innovative products with maximum wear comfort.

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