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Mini-Review Article

Methods of Assessing the Performance Characteristics of Sportswear

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Abstract

Performance sportswear enhances the performance of athletes by imparting special functionality like reducing drag resistance as well as providing maximum wear comfort and protection in extreme weather conditions such as rain, snow, extreme cold, and heat. Innovative materials and remarkable technologies are emerging very fast in this area to provide that extra benefit to players for enhanced performance. Ultimately assessment of such engineered sportswear becomes necessary to choose the right sportswear for right sport, environmental conditions, and wear comfort of the sports persons. In the present paper, the authors have tried to overview the various standard testing methods used for assessing performance characteristics of Sportswear that include sport clothing and sport shoes and also floor coverings, enumerating their functional properties.

Keywords: Resistance to water; Spray test; Air permeability; Rain-shower test; Antibacterial finishes; Thermal insulation.

Introduction

The growth of textile industry provides various high quality products with added and specific values. Construction / engineering & Finishing of textile materials with different chemicals and nanoparticles and production of nanofibers revolutionized the sportswear market. The textile substrates impart unique multifunctional properties without adverse effect on breathability or hand-feel. Sport shoes with antiodor, waterproof and antibacterial insoles, waterproof swimsuits and protective sport clothing with high-impact resistance are among the wide applications of new technologies in sportswear. Athletes' safety and physical comfort are also increased by wearing the specialised sport clothes [1-5].

Properties and Standard testing methods

Standard methods required for assessing the different properties of sportswear are briefly given in Table 1. To define the degree of thermal comfort of a garment objectively, international standards have been developed based on the objective and representative measuring methods of five properties of textile materials, which have a determining influence on the thermal regulation of garments:

(i) Thermal insulation;
(ii) Resistance to the transfer of water vapour;
(iii) Permeability to air;
(iv) Resistance to the penetration of water; and
(v) Wicking.

These five methods allow the classification of thermoregulation properties of a garment and are of great importance to the producers of work wear, sportswear, and any kind of thermoregulating garments. To assess thermophysiological comfort of the entire garment, the insulation and permeability of clothing are usually measured in a static state on a thermal manikin, expressed by the thermal insulation parameter (clo) and permeability index. The thermal manikin allows thermal insulation and moisture transport of the entire garment to be measured while simulating the body heat and transpiration of a person in action (eg, work, sports, walking), exactly simulating their effects for the wearer in practical use.

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Table 1. Standard Methods for assessing properties of Sportswear

Property	Standard No.	Title
Water-proof and breathability	ISO 811: 1989 BS EN 20811: 1992	Textile fabrics, determination of resistance to water penetration, hydrostatic pressure test
	ISO 4920:2012	Textiles, determination of resistance to surface wetting (spray test) of fabrics
	ISO 15496: 2004	Textiles, measurement of water vapor permeability of textiles for the purpose of quality control
	BS 5636: 1990 ASTM D737-04: 2012 BS EN ISO 9237: 1995	Textiles, determination of the permeability of fabrics to air
	BS EN 29865: 1993 ISO 9865: 1991	Textiles, determination of water repellency fabrics by the Bundesmann rain-shower test
	AATCC 35-2006 BS 5066: 1974	Method of test for the resistance of fabrics to an artificial shower
Antibacterial	AATCC 100: 2004	Antibacterial finishes on textile materials
	AATCC 147: 2004 s	Antibacterial finishes on textile material
UV protection	AS/NZS 439 9:1996	Sun protective clothing, evaluation and classification
	AATCC 183: 2014 ASTM D6544: 2012	Transmittance or blocking of Erythemally weighted ultraviolet radiation through fabrics
Self-cleaning	ISO 27448: 2009	Test method for self-cleaning performance of semiconducting photocatalytic materials. Part 1: Measurement of water contact angle
Hot and cold protection	ISO 20344: 2004	Personal protective equipment, test methods for footwear
	EN 12784: 2000	Footwear, test methods for the whole shoe: thermal insulation
	ISO 15831: 2004	Clothing, physiological effects, measurement of thermal insulation by means of a thermal manikin

Water-proof breathability

To study the Water-proof breathability of fabrics, the method based on spray test ISO 4920:2012, in which the fabric resistance to surface wetting is investigated by spraying the specific amount of distilled water and comparing the sample with standard pictures [6]. It is also important to determination of resistance to water penetration based on hydrostatic pressure and it is conducted by subjecting the fabric sample to a steadily increasing pressure of water on one face until penetration occurs (ISO 811: 1989, BS EN 20811: 1992) [7,8].

Water-vapor permeability

Moisture transport property which is affected by wicking and evaporation rate is an important aspect of sportswear, affecting the comfort level of the wearer. Faster wicking of moisture through fabric improves the evaporation due to higher surface area, leaving the wearer dry and comfortable. Fabrics with moisture transport properties transfer moisture from the wearer's skin surface into the fabric surface, and release the moisture to the atmosphere. These functional fabrics transfer sweat and moisture from the surface of the skin to the outer surface of the fabric, which keeps the wearer's body dry and comfortable and prevents clinging of polyester fabric to the wearer's body.

The resistance to water-vapor permeability is also studied according to ISO 15496: 2004, in which fabric weight change is related to breathability and the value more than 20,000 g/m^2 per day is regarded as a sample with high breathability [2]. Determination of water repellency of fabrics by Bundesmann rain-

shower test (ISO 9865: 1991 and BS EN 29865: 1993) and AATCC 35-2006 and BS 5066: 1974 rain tests are among the other standard methods associated with water-proof breathable fabrics [9-16].

Antibacterial

Considering the importance of public health awareness, there is an increasing demand for antibacterial materials in many application areas including sport. Sweating during sport activities provides suitable environment for bacteria to grow and generate bad odor. *Staphylococcus aureus* is a common bacterium in athletic teams causing infectious diseases. Thus, antibacterial sport clothing can protect the athletes against microorganisms and unpleasant odors whilst preventing the fibers from damage and rotting. Antibacterial property of fabrics is generally evaluated using quantitative and qualitative tests based on AATCC100 and AATCC 147, respectively. The most common Gram-positive and Gram-negative bacteria are *Staphylococcus aureus* and *Klebsiella pneumonia*, while other microorganisms such as Escherichia coli can be also used. Quantitative method is based on calculating the reduction percent of bacteria at zero contact time and after 24h from the inoculated treated test specimen and control sample (with no antibacterial agent). In the qualitative test a clear area of interrupted growth underneath and along the side of the test material indicates antibacterial activity of the specimen [17,18].

Ultraviolet protection

Ultraviolet protection factor (UPF) is a rating system used for apparel that indicates how effectively fabrics shield skin from UV rays. The higher the UPF number, the greater degree of UV protection a garment offers. Any fabric that allows less than 2% of UV transmission is labeled UPF 50+. AATCC 183 and ASTM D6544 both describe the methods used for evaluation of UPF factor of apparels [19,20]. Although the self-cleaning performance of ceramics coated with nano-photocatalysts is determined based on ISO 27448-2009 through measurement of a change in water contact angle of surface under UV irradiation, no standard method has been proposed for textile materials so far [21].

Self-cleaning property

One of the successful applications of nanotechnology in textile industry is the production of sport clothing and mountaineering tents with self-cleaning property. Apart from engineering a superhydrophobic surface using the lotus effect, photocatalytic nanoparticles such as TiO_2 and ZnO have been used to produce hydrophilic surfaces with self-cleaning activity, and the photocatalytic self-cleaning fabrics could be applied for sportswear. Self-cleaning efficiency of textiles due to nano-photocatalyst incorporation is generally evaluated by staining the samples with dyes or coffee and observing the stain degradation under various light irradiations. ISO 15831:2004 standard method is used for measurement of thermal insulation of clothing using a thermal manikin. The method is based on measuring the temperature difference between the wearer's skin surface and ambient atmosphere per unit area. The manikin is stable or moves at specific intervals [22]. ISO 20344:2004 and EN 12784: 2000 standard methods determine the insulation property of shoes against hot and cold by measuring the thermal changes in innersoles and footwear [23,24].

Conclusions

The future approach in developing sportswear will be focused on fulfilling multifunctional requirements including temperature regulation, friction reduction, moisture management, high strength, elastic recovery, lightness, wind andwater resistance and wear comfort along with other characteristics depending on the nature of the sport, climatic conditions and physical activity, to develop enhanced performance products.

Conflicts of Interest

Authors declare no conflict of interest.

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