

Effect of some comfort properties on performance properties of sports abaya fabrics for women

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Abstract

Sports have received great attention in the Kingdom of Saudi Arabia's vision 2030, as it was stated that the government will support sports of all kinds, and expand opportunities associated with this trend. As a result, Saudi women have increased their interest in outdoor sports activities, which has led to a growth in the production of sports *abaya*. A sports *abaya* is worn over daily clothes while outdoor-exercising. The presence of multi-layers of clothing negatively affects the fabric's air permeability. Therefore, fabrics used in sports *abaya* must be highly air permeable, to allow the transference of heat and moisture from the skin surface to the environment. The present study aims to investigate the effect of structural properties and porosity on the air permeability of the sports *abaya* fabrics. Two variable samples of fabrics (100% knitted cotton-white, 100% woven polyester-white) and two fixed samples (100% knitted cotton-black, 100% knitted polyester-orange) were used in producing and testing two models of sports *abayas*, with solo variable between the models. It was found from the results that, through a comparison between the variable samples, 100% woven polyester-white recorded a better air permeability value of 44.9 ml/cm²/s, and porosity of 109.23 pixels / μm², than 100% knitted cotton-white. This is due to the fact that the 100% woven polyester fabric has a higher porosity, and is made of fine polyester yarn. The results confirm that the use of 100% woven polyester-white fabric in producing sports *abaya* will provide greater comfort for the wearer for his ability to transfer heat and moisture well in terms of air permeability. Therefore, sports *abaya* model, which contained a 100% woven polyester fabric sample, was superior to the sport *abaya* model that contained 100% knitted cotton fabric in the level of air permeability. The results of the current study confirmed the existence of a direct-proportion relationship between the fabric's air permeability and its porosity, and an inverse relationship with some structural properties. The study also found out that the use of net fabric in the production of the sports *abaya* will greatly improve comfort in wearing, due to its high air permeability.

Keywords: Thermal comfort, Air permeability, Physical properties, Porosity.

Introduction

The Kingdom of Saudi Arabia has witnessed fundamental changes in giving women their full family and social rights, and accordingly, Saudi women have recently increased their interest in practicing sports and participating in many physical activities, including outdoor walking. And based on the Kingdom's vision 2030 in building a vibrant society by enhancing the

individual's life, encouraging the practice of sport in the community to reach excellence in many physical sports regionally and globally, opening windows for sports investment and supporting opportunities associated with this trend ("Quality of Life Program | Saudi Vision 2030"). This led to a growth in the production of sports abaya in the local market due to the increasing demand of women for it. Abaya, in general, is a women's garment that is worn over the daily clothes to cover the entire body when leaving the house. The traditional abaya can be described as a long robe, open to the front with buttons or zippers, with long sleeves, revealing the face, hands, and feet, usually in black color, and it is also worn with a scarf (scarf) to cover the hair (Tashkandi, Wang, and Kanesalingam 2013a). Sports abaya differs from the traditional abaya in the design of the abaya itself, as the sports abaya may consist of one piece with a trouser design at the bottom of the abaya to contribute in improving comfort and performance of the wearer. However, the presence of multiple layers of clothing may adversely affect the air permeability of the fabrics and the body temperature (Manshahia and Das 2014; Çeven and Günaydin 2018; Tashkandi, Wang, and Kanesalingam 2013a). The movement of moisture from the surface of the skin to the environment is closely related to the permeability of the fabrics to the air, because it plays an important role in facilitating the transfer of moisture vapor by diffusion into the air through the fabric porosity (Karaguzel 2004; Wang et al. 2019). An athlete who wears poorly ventilated sportswear may have a higher heart rate and body temperature than someone who wears well-ventilated sportswear (Hassan et al. 2012). Thus, sportswear must be highly efficient in transferring heat and moisture (sweat) from the surface of the skin during various activities and dissipating it to the external environment (Karaguzel 2004; Bhattacharya and Ajmeri 2013). Therefore, the current research aimed to investigate the air permeability of two variable samples and two fixed samples of fabrics used in producing two models of sports abaya. In addition, investigate the effect of physical properties and porosity on air permeability.

Research problem

The research problem is summarized in the following questions:

- 1- What is the influence of physical properties and porosity on the performance properties of sports abaya fabrics?
- 2- To what extent does the air permeability of fabric samples contribute to improving the performance properties of the sports abaya?

Research importance

- 1- Enhance the sports abaya industry by linking the physical and thermal comfort properties of fabrics.
- 2- Producing high quality and comfortable sports abaya.

Research aims

- 1- Investigate the physical properties, porosity, and air permeability of samples of fabrics used in sports abaya.
- 2- Verifying the effect of physical properties and porosity on air permeability of samples of fabrics used in sports abaya.
- 3- Verify the extent to which laboratory tests contribute to determining the most suitable fabric for producing sports gowns used in hot and humid environments.

Research hypotheses

- 1- There are statistically significant differences in the physical properties between samples.
- 2- There is a correlation between the porosity and air permeability of the research sample.

3- There is a correlation between (number of thread and thickness) and the air permeability of the research sample.

Research limits

Makkah Al-Mukarramah Region, Jeddah.

The current research is limited to the sports abaya for Saudi women, which is used when practicing outdoor sports.

Research Methodology

The research followed the experimental method in conducting laboratory tests on some fabrics used in the production of sports abaya.

Research terms

Thermal comfort

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has defined thermal comfort as "the state of mental satisfaction expressed in a thermal environment" (Handbook – Fundamentals 1997). Thermal comfort in the concept of clothing is the ability of clothes to maintain the temperature of the human body as the physical and mental condition of the human body and its performance is directly affected by thermal comfort (Tashkandi 2014).

Porosity

fabric's porosity is defined as the difference between the total area of the fabric and the expected area covered by the threads (Karaguzel 2004).

Air permeability

Air permeability in fabrics is defined as the rate of air flow in liters that passes perpendicularly through a specific area of fabric, under a specific pressure difference per unit time. It is a measure of how well the fabric allows air to pass through it (Wang et al. 2019; Sarioğlu and Babaarslan 2019; Partridge, Mukhopadhyay, and Barnes 1998).

Material and methods

Research tools

Fabrics

The current research includes four samples of fabrics used in producing two models [Model 1, Model 2] of sports abaya, in partnership with a local clothing manufacturer - "Lomar" for Saudi thobe -. A single variable was created between the two models in order to determine the most suitable fabric in the production of the sports abaya. Sample (a) 100% knitted cotton -white was added to [model 1], and sample (b) 100% woven polyester-white to [model 2], the fabric has been integrated from the shoulders to the front and back of the sports abaya. The two models are similar in design, sample (c) 100% knitted cotton-black, on the sides of the sports abaya, and sample (d) 100% knitted polyester-orange in underarm and upper back of the sports abaya. Figure (1) shows the design of the sports abaya.

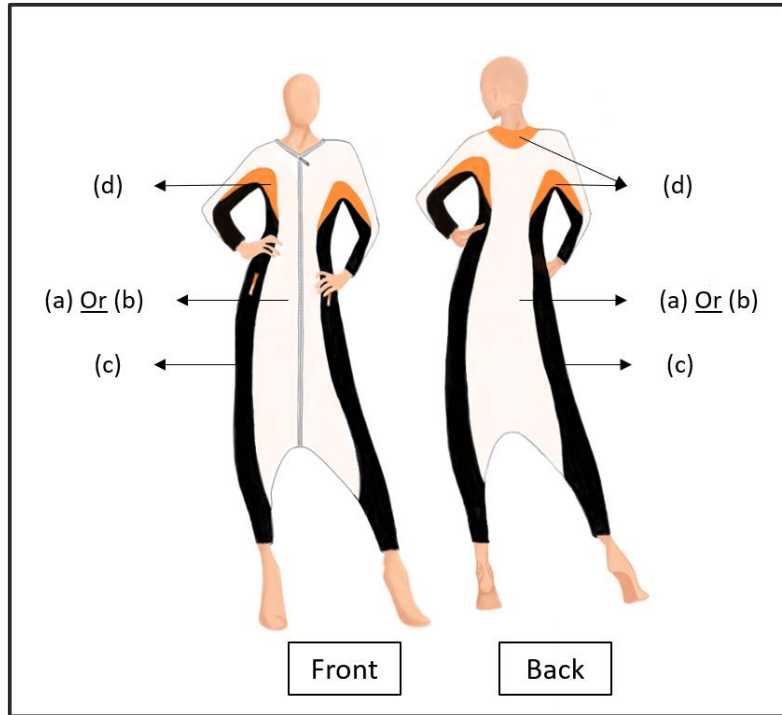


FIGURE 1 A DRAWING OF A SPORTS ABAYA DESIGNED USING DIFFERENT FABRICS

Testing method

1- Physical properties tests

The tests of physical properties of samples of the fabrics were carried out in the laboratory (Pyruvirtas, Jeddah, Kingdom of Saudi Arabia) according to testing standards as following:

- Material weight test (mass per unit area) according to SASO ISO 3801: 2001*
- Thickness test according to ASTM D 1777: 2007*
- Textile composition according to SASO ISO 7211-1: 2006.
- Yarn count according to SASO ISO 7211-5: 2006.
- Thread density for (knitted fabrics) according to SASO 1170: 1997, and for (woven fabrics) according to SASO 183: 2002.

* SASO - Saudi Standards, Metrology and Quality Organization; ISO-International Organization for Standardization; ASTM- Standard Specification for the American Society for Testing and Materials.

2- Porosity test

An optical microscope was used to calculate the porosity of the fabrics (research samples), by attaching the optical microscope to a fast digital camera using a magnification power X 4 lens. (5) pictures were taken for each sample and displayed on the computer via the (Top View) program. The program calculates the porosity of the sample by applying mathematical operations to the image using the OTSU algorithm (OTSU. Dark) or (OTSU. Bright). Otsu's algorithm is named after Nobuyuki Otsu (Sezgin and Sankur 2004). In its simplest form, the algorithm separates image pixels into two classes (front and background), and this is determined by reducing the indication of intensity within the category, or equivalently, by increasing the contrast between classes (Otsu 1979). It is expressed in pixels / μm .

3- Air permeability test

The air permeability test was performed in the Brunswick Sustainable Laboratory at RMIT with the following measuring specifications: The air permeability test was performed with the M021S from SDL ATLAS Ltd according to EN ISO 9237 - 1995 standard, to measure the air permeability of the research samples, by drawing air through the sample with a vacuum pump. The air flow was measured with a flowmeter (1 in 4) against a specific pressure drop, which was indicated by the manometer. Air permeability test results are expressed in ml/cm²/s at specified pressure. The test device includes 4 flow meters that cover a range of air flows from 5ml/min to 25L/min, selected and adjusted by the front switches of the device. The valves also regulate the air flow through the sample and the specified flow meter, then flow readings are taken when the manometer indicates a drop in the specified pressure.

The air permeability and average air flow were measured for four samples of different fabrics under a pressure of 100 Pa. The working area on one sample was 5 cm², at a temperature of 20°C and the humidity of 60% within 24 hours.

Results and discussion

Property	Variable samples		Fixed samples	
	a	b	c	d
Composition	100% knitted cotton	100% woven polyester	100% knitted cotton	100% knitted polyester
Yarn count	16.3	Wrap: 11.4 Weft: 14.0	15.5	-
Thread density per cm	Wales: 16 Courses: 23	Picks: 85.6 Ends: 45.3	Wales: 16 Courses: 23	Wales: 15 Courses: 14
Structure	Single jersey	Satin weave	Single jersey	Mesh
Thickness (mm)	0.61	0.56	0.60	0.50
Weight (g/m²)	193	204	186	106
Porosity	86.83	109.23	108.04	206.56
Air permeability	24.10	44.98	27.76	-

It was found out from the results that, through a comparison between the variable samples, the 100% woven polyester-white recorded a better air permeability value of 44.9 ml/cm²/s, and a porosity of 109.23 pixels / μm², than the 100% knitted cotton-white. This is due to the fact that the 100% woven polyester fabric has a higher porosity and is made of fine polyester yarn. The results confirm that the use of the 100% woven polyester-white fabric in producing the sports abaya will provide a greater comfort in wearing for its ability to transfer heat and moisture well in terms of air permeability. Thus **Model 2** of sport abaya which containing 100% woven polyester fabric is superior to **Model 1** which is containing 100% knitted cotton-white in the level of air permeability. The results of the current research confirmed the existence of a direct-proportion relationship between the fabric's air permeability and its porosity, and an inverse-proportion relationship with thickness and yarn count. The

research also found out that the use of net fabrics in the production of the sports abaya will greatly improve the comfort in wearing, due to its high air permeability.

Conclusion

laboratory tests have helped to determine the most suitable fabric to produce sports abaya used in hot and humid environments. The current research results showed the superiority of the 100% woven polyester fabric sample in air permeability for the variable samples, due to the high number and size of pores compared to 100% knitted cotton sample, which makes the 100% woven polyester sample the best fabric for use in producing sports abaya, for its ability to provide thermal comfort to the wearer in terms of air permeability. In addition, 100% knitted polyester-orange, which has a mesh structure, achieved the highest results in air permeability.

Research recommendations

- 1- Conducting further research studies aimed to investigate the thermal comfort properties of fabrics used in the manufacture of modest sportswear for regions with hot and humid climates.
- 2- Considering the use of fabrics with high air permeability in the manufacture of sports abaya, to provide the greatest thermal comfort to the wearers.
- 3- The apparel factories make use of modern fabrics for sportswear to develop production, and manufacture sportswear locally with high quality.

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