

Thermal Conductivity Properties of Men's Quick-Dry Sportswear

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Abstract

This study evaluated the thermal conductivity properties of summer men's sportswear T-shirts of different brands (Nike, Adidas, Laishilong and Columbia) available in Hong Kong market were evaluated. It was found that the samples of Nike, Laishilong and Adidas showed similar heat-conducting behavior due to their comparable thermal conductivity results, whereas the poorest thermal conductivity was seen in Columbia sample.

Keywords: Thermal conductivity, Quick dry property, Fabric structure, Sportswear

INTRODUCTION

Thermal conductivity refers to the ability of the fabric to transfer and conduct heat, and it is inversely proportional to thermal resistance which is related to the insulation of the fabric [1]. The term thermal absorptivity measures the warm-cool feeling of the fabric at first sensation with the skin which depends on thermal conductivity [2]. Thermal conductivity can be influenced by the thickness, fabric areal density and wetting, and high thermal conductivity allows rapid heat transfer. An increase in thickness of fabric could enhance the thermal conductivity [3].

Sportswear was designed with the improvement of properties such as quick-dry, waterproof and thermal comfort [4]. With the quick-dry property, the sportswear can bring the property that the sweat can be fast transferred through the cloth and keep the body dry. Since quick-dry sportswear has become more and more popular recently, different sport brands such as Nike and Adidas have explored a variety of different materials and technologies to produce its own quick-dry sportswear in the market [5]. However, people are not able to find out the most suitable sportswear because there was lack of a criteria determining the quick-dry performance for different clothing. Moreover, other applications of quick-dry sportswear were

lack of literature research. It is unclear to know the quick-dry performance of different sportswear. As a result, customers may be unsatisfied on the product performance after purchases. Hence, the present research aims to comparatively study the heat-conducting properties of summer men's sportswear T-shirts of different brands available in Hong Kong market by analyzing the thermal conductivity.

EXPERIMENTAL

Fabric samples

Four summer men's running T-shirts of different brands, i.e., Nike, Adidas, Laishilong and Columbia, were selected for this study. These running T-shirts were claimed and advertised that they can keep human body dry with excellent quick dry behavior when people are exercising. The samples are single and double jersey but with different colors, fiber types and content. Cotton and polyester are the major fibers, including the recycled polyester and spandex, used in the fabric samples. Detailed fabric specification was shown in Table 1.

Table 1. Specification of tested samples.

Item		Sample specification			
Brand		Nike	Adidas	Laishilong	Columbia
Composition		85% polyester 15% cotton	Front body: 61% polyester recycled and 39% polyester; Back body: 51% polyester and 49% polyester recycled	100% polyester	Shell face: 100% polyester; Side panel: 86% polyester and 14% elastane
Color		Grey	Black	Black	Blue
Fabric structure		Single Jersey	Double Jersey	Double Jersey	Double Jersey
Fabric weight (g/m ²)		130.61	128.41	142.76	77.74
Fabric thickness/mm		0.299	0.328	0.292	0.194
Fabric density	Wale/cm	With holes: 18 Without holes: 13.5	Front body:18 Back body:18	17.5	25
	Course/cm	With holes: 17 Without holes: 27.2	Front body:19 Back body:23	20	30

All samples before testing were conditioned with the temperature $20\pm 2^{\circ}\text{C}$ and relative humidity $65\pm 2\%$ for at least 24 hours. After conditioning, samples were used in physical testing and all the experiments were carried out under standard testing condition.

Surface morphology analysis

The surface morphology of sportswear samples was observed by the Digital Microscope (Leica DVM6, Hamburg, Germany).

Thermal conductivity evaluation

To better understand the heat transfer ability of the T-shirts, the thermal conductivity test was conducted using Thermo Labo II tester KES –F7, which measures the amount of heat energy transfer from the hotter surface to the cooler surface via conduction method. For this instrument, the temperatures of BT-plate and the guard plate in the BT-Box were pre-set to 30°C and 30.3°C respectively. BT-Box directly contacts with the inner face of the fabric and water box contacts with surface of fabric. The heat loss from the BT-box through the test specimen to the Water box in watts was recorded by digital panel meter that showed the temperature difference (ΔT) between the metal plates in BT-box and water box. According to the standard of KES –F7, thermal conductivity test was conducted as follows:

1. Thickness of fabric was measured by the fabric thickness tester.
2. Power switch, BT Heater and Guard Heater were switched on machine were turned on and machine was stabilized for 10 minutes.
3. “W Range” set dial was set to Warm Up (200W) and W button next to set dial was pressed.
4. Temperature of water source for water box was set to 21°C .
5. Water with room temperature was circulated from water source to water box.
6. Temperature of BT-box was set to 30°C by turning BT temperature set dial and it should be kept in constant.
7. Temperature of guard should be reached to around 30.4°C and it should be kept in constant since guard temperature is required to be higher than BT-box for around $0.3\text{-}0.4^{\circ}\text{C}$.
8. The temperatures of guard and BT-box were checked by pressing the button of qm and BT.

Thermal conductivity is expressed by k value and calculated by following Eq. 1. Fabrics with higher K value have greater thermal conductivity to transfer heat from body through its surface.

$$k = \frac{W \times D}{A \times \Delta T} \quad (1)$$

Where, k = thermal conductivity ($\text{W}/\text{cm} \cdot ^{\circ}\text{C}$); W = Data average; D = average thickness of samples; A = area of heat plate of BT-Box = 25 cm^2 ; ΔT = Temperature difference of BT-Box (30°C) and water box (21°C) = 9°C .

To convert it into SI unit (W/mk):

$$K_{\text{SI}} (\text{W}/\text{mk}) = k \times 10^2$$

RESULT AND DISCUSSION

Fabric appearance and structure analysis

The appearance and fabric structure of four samples were shown in Figure 1. Two samples, Nike and Adidas, were knitted by single jersey, while the other two samples, Laishilong and Columbia, were knitted by double jersey with specific techniques. The miss stitches were applied on the back body of Nike T-shirt to create the holes on the fabric. For the Adidas's T-shirt, there were two tensions of the double jersey applied on the front body of garment, thus to create subtle disruptive pattern. Its back body was knitted by plain single jersey but every three wales has constant tension and then one wale has different tension. The whole garment of the Laishilong's T-shirt was knitted by plain stitches. The fabric structure of Columbia's T-shirt was special knitted by every 5 wales of front loops with 1 wale of back loops. Also, every 5 courses plain stitches were knitted and followed with 1 course of tuck stitches. Therefore, the overall fabric structure of Columbia's T-shirt seems plaid pattern.



Figure 1. Appearance and fabric structure of fabric samples of different brands: Nike (A, a), Adidas (B, b), Laishilong (C, c) and Columbia (D, d).

Thermal conductivity analysis

The mean values of thermal conductivity of fabric specimens from four brands were conducted and shown in Figure 2. As can be seen clearly, the thermal conductivity seems more or less comparable in general, especially for the samples of Nike, Laishilong and Adidas. By contrast, only the sample of Columbia had comparatively lower thermal conductivity (0.024 W/mk).

The fabric without holes from Nike and the fabric of Laishilong had relatively higher thermal conductivity. The difference of thermal conductivity between the fabrics with and without holes from Nike was small. However, the difference of thermal conductivity between the front body fabric and back body fabric from Adidas was obvious that front body fabric had

higher thermal conductivity. For the fabric of Columbia, its thermal conductivity performance was the poorest one. Besides, the fluctuation of thermal conductivity values for Laishilong sample was larger than the others. This implies that the measurement stability was low thus the calculated records were different in each time.

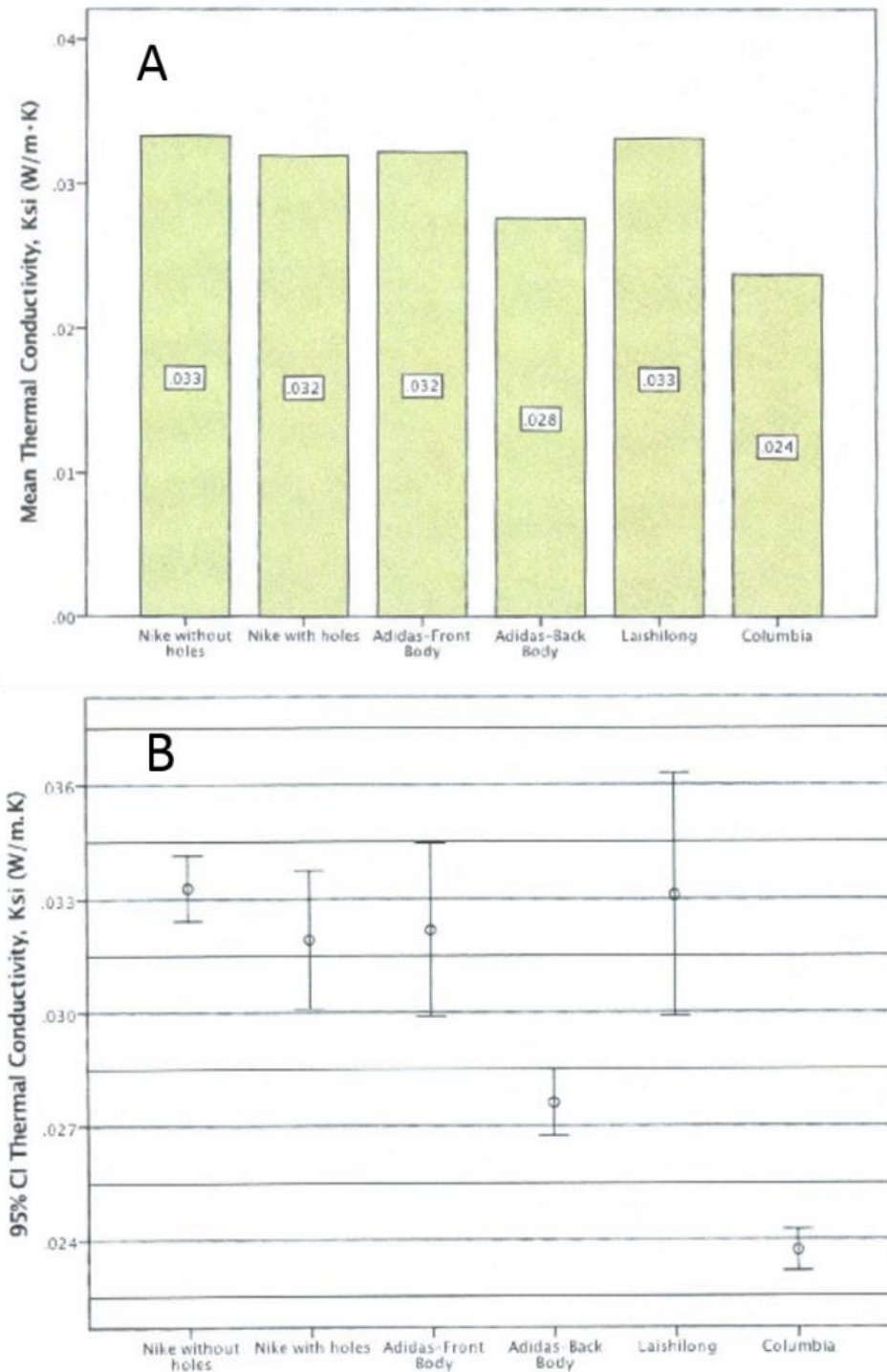


Figure 2. Mean thermal conductivity of samples of different brands (A) and the difference (B).

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Table 2. One –way ANOVA results of thermal conductivity test.

	N	Mean	Std. Deviation	Std. Error	95 % Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Nike without holes	5	.0333	.00070	.00031	.0324	.0341	.03	.03
Nike with holes	5	.0319	.00147	.00066	.0301	.0337	.03	.03
Adidas-front baby	5	.0322	.00184	.00082	.0299	.0345	.03	.03
Adidas-back body	5	.0276	.00071	.00032	.0267	.0285	.03	.03
Laishilong	5	.0331	.00258	.00115	.0299	.0363	.03	.04
Columbia	5	.0237	.00045	.00020	.0232	.0243	.02	.02
Total	30	.0303	.00381	.00070	.0289	.0317	.02	.04

The one-way ANOVA analysis (Table 2) further indicates that there was an overall significant difference in thermal conductivity among all fabric types ($F=32.970$, $p=0$, $\alpha=0.05$). The difference of mean thermal conductivity between Columbia and others, and the back body fabric of Adidas were statistically significant at $\alpha=0.05$ ($p<\alpha=0.05$). This reflects that the mean value of thermal conductivity of Columbia fabric and back body fabric of Adidas were obviously smaller than the others. By comparing Columbia fabric and back body fabric of Adidas, the mean thermal conductivity of Adidas was comparatively higher than that of Columbia which shows the thermal conductivity of Columbia was the lowest.

CONCLUSIONS

In this study, the thermal conductivity properties of summer men's sportswear T-shirts of different brands available in Hong Kong market were evaluated. It was found that the mean value of thermal conductivity of fabric specimens seems more or less comparable, especially for the samples of Nike, Laishilong and Adidas. By contrast, the Columbia sample had the lowest thermal conductivity.

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