An Analysis of Air Permeability of Men's Quick-Dry Sportswear

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Abstract: Air permeability is one of the thermal comfort properties of clothing and fabrics. This study evaluated the quick dry properties of summer men's T-shirts of different brands (Nike, Adidas, Laishilong and Columbia) by studying the air permeability behavior. Both Nike and Adidas samples were knitted by single jersey, while double jersey was used for Laishilong and Columbia T-shirts. The materials for Adidas, Laishilong and Columbia were polyester while Nike was made of cotton and polyester. Overall, both Nike and Adidas were found to perform better in terms of air permeability than those of Laishilong and Columbia.

1 Introduction

There are three ways for heat transfer between two surfaces, i.e., conduction, convection and radiation. Factors affecting clothing heat transfer are the amount of air contained within the structure, direction of fiber arrangement, atmosphere temperature, humidity and moisture content of fabric [1]. The amount of air contained within the structure is controlled by the crimp of fiber. The crimp usually depends on fabric structure and the tension in the fabric during weaving. External atmospheric conditions affects heat transfer, which decreases while temperature increases and humidity decreases.

Different clothing and fabric properties are critical in maintaining the thermos physiological comfort under different conditions and physical activities since clothing is part of thermo-regulatory system [2]. It was reported that the thermal, moisture and air permeability properties are main factors affecting the thermal comfort of clothing and fabric [3]. Also, the thermal regulation function as well as the sensory comfort on warm or cool feeling are dependent on both heat and moisture transfer properties of fabrics [4]. It was mentioned that the thermal resistance and air permeability of fabrics are vital factors controlling the thermal comfort of the wearer, and fabrics must have low thermal resistance and high air permeability properties in order to provide higher thermal comfort for wearers during workouts [5].

Air permeability measures the rate of air flow via a test material under a different air pressure between two surfaces of that material, which is related to thermal comfort properties [6]. High air permeability allows quick transition of moisture, facilitating the heat transfer process, which is of high importance for the sportswear with quick dry properties [7]. The present study aims to comparatively evaluate the quick dry properties of sportswear by analyzing the air permeability behavior.

2 Experimental

2.1 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.

All samples before testing were conditioned with the temperature 20±2°C and relative humidity 65±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.

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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

2.2 Surface morphology analysis

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

2.3 Air permeability evaluation

Air permeability is a fabric property that related to heat and moisture transfer, which was defined as "the degree to which the material is penetrable by air". The air permeability test, according to KES-F8, was used to test the air resistance of fabric by measuring the air flow that passes perpendicularly through a given area of a textile fabric at a given pressure over a given period of time from high air pressure to low air pressure. Piston motion of plunger or cylinder mechanism generated and provided constant rate of air flow and then air passed through a specimen into the surrounding environment. Air suction and discharge periods are 5 seconds respectively. Air resistance of the specimen causes air pressure loss was measured by a semiconductor differential pressure gauge.

The test was conducted according to the standard method for Air Permeability testing (KES-F8) and the steps of experiment are shown below:

1. Fabric sample was cut in the size larger than 2.9cm.
2. Machine was turned and "SENS" set dial was turned to "M".
3. Machine was adjusted to zero by pressing "Reset" button to remove the past record.
4. Right side of fabric sample was faced down and placed carefully on the testing area of air permeability tester in order to prevent changing size and shape of the specimen.
5. Metal cover with 2.9cm opening was put down and two rings were clamped on both sides of metal cover to stabilize the fabric between metal cover and sample base.
6. "Start" button was pressed to start the suction device. The reading shown on the digital screen of machine was recorded when the desired depression was stabilized.
7. The rings clamped on metal plate were removed.
8. Steps 4 to 7 were repeated until all specimens were being tested.

Air permeability performance of fabric can be determined by directly reading to testing results. The smaller the result is, the higher the air permeability performance of fabric.

3 Results and Discussion

3.1 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.

3.2 Air permeability analysis

Air permeability test is closely related to heat and moisture comfort of clothing which is a crucial test for summer sportswear. According to KES-F8 standard, air permeability of fabric is determined directly by air permeability machine. The smaller the testing result, the better the air permeability. The results of air permeability of different fabric types are presented in Figure 2 to compare the mean values. It can be observed that fabric with holes from Nike and the back body fabric from Adidas had the lower air permeability. This implies that they had comparatively better performance in terms of air permeability. Nike and Adidas had outstanding performance in air permeability while Laishilong and Columbia performed relatively poorer.

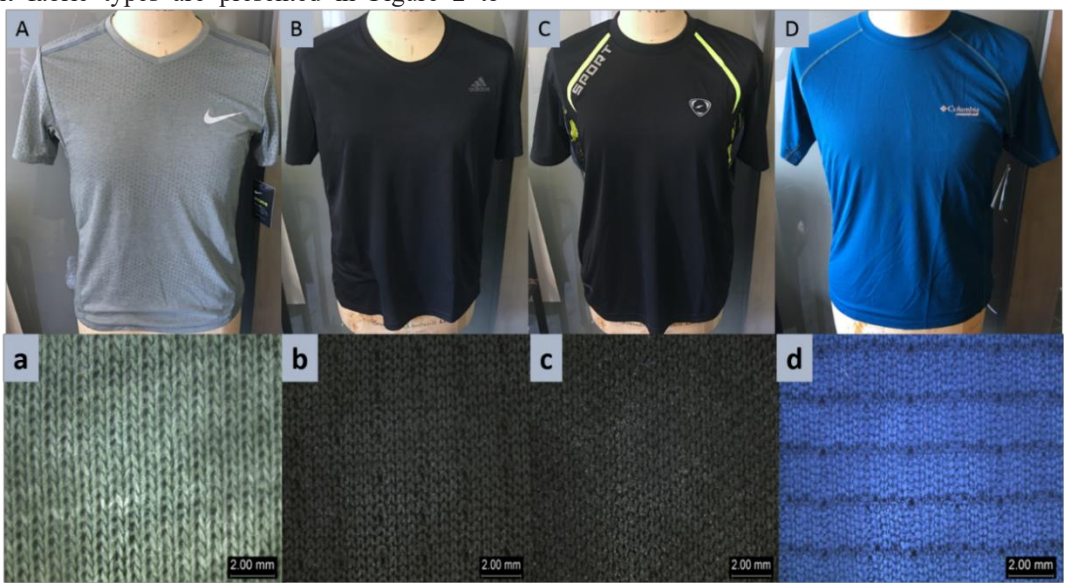

Figure 1. Appearance and fabric structure of fabric samples of different brands: Nike (A, a), Adidas (B, b), Laishilong (C, c) and Columbia (D, d).

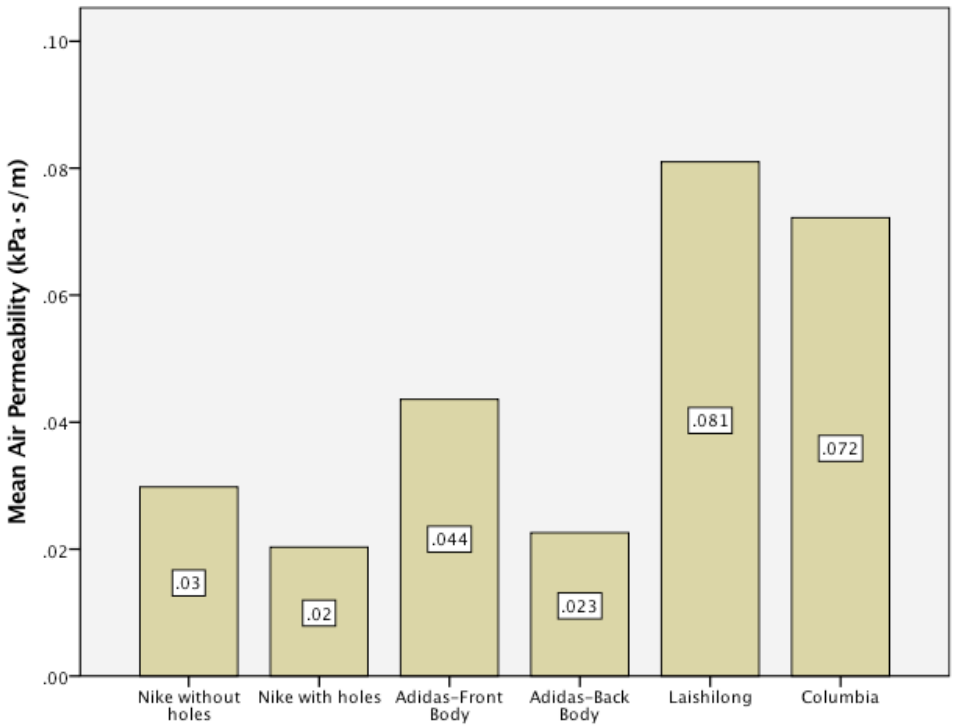

Figure 2. Mean value of air permeability of samples.

From Figure 2, the T-shirt with holes of Nike showed the best performance with regard to air permeability (0.02 kPa·s/m), compared with Adidas (0.44 kPa·s/m for front body and 0.23 kPa·s/m for back body), Laishilong (0.081 kPa·s/m) and Columbia (0.072 kPa·s/m). The air permeability performance of Nike and Adidas were over

50%, better than that of Laishilong and Columbia. Besides, there was significant difference of air permeability performance between Nike's T-shirt with two knitting methods or between front and back body of the T-shirt from Adidas, especially for Adidas. The air permeability result of back body has 50% better than that of front body. The reasons may be due to fabric properties, such as fabric density and porosity, material used and thickness. Table 2 shows the one-way ANOVA of air permeability of different samples. Clearly, there was an overall significant difference in air permeability among all fabric types ($F= 15.475$, $p = 0 < \alpha = 0.05$). The difference of mean air permeability between Columbia and others (except Laishilong) was statistically significant at $\alpha = 0.05$. Its mean value was obviously larger than the others (except Laishilong). The difference of mean air permeability either between the front body fabric of Adidas and fabric with holes from Nike ($p = 0.039 < \alpha = 0.05$) or between the front body fabric of Adidas and its back body fabric ($p = 0.006 < \alpha = 0.05$) were also statistically significant at $\alpha = 0.05$. This implies the mean value of front body fabric from Adidas had a crucial difference (larger mean value) with fabric with holes from Nike and back body fabric from Adidas, respectively.

Table 2. One-way ANOVA results of air permeability test.

Brands	N	Mean	Std. Deviation	Std. Error	95 % Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Nike without holes	5	.0298	.00683	.00306	.0213	.0383	.02	.04
Nike with holes	5	.0203	.01095	.00490	.0067	.0339	.01	.04
Adidas-Front Body	5	.0436	.00635	.00284	.0357	.0515	.04	.05
Adidas-Back Body	5	.0226	.00230	.00103	.0197	.0255	.02	.03
Laishilong	5	.0810	.03207	.01434	.0412	.1208	.04	.13
Columbia	5	.0722	.00835	.00373	.0618	.0826	.06	.08
Total	30	.0449	.02763	.00504	.0346	.0552	.01	.13

4 Conclusion

In this study, the quick dry properties of summer men's T-shirts of different brands available in Hong Kong market were evaluated by studying the air permeability behavior. Fabrics of Nike and Adidas were knitted by single jersey, while Laishilong and Columbia were knitted by double jersey. The fiber for Adidas, Laishilong and Columbia were polyester while Nike was made of cotton and polyester.

The sample with holes of Nike showed the best performance with regard to air permeability, compared with Adidas, Laishilong and Columbia. Overall, both Nike and Adidas were found to perform better in terms of air permeability than those of Laishilong and Columbia.

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