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SOME STUDIES ON THE THERMOPHYSIOLOGICAL COMFORT OF HIJAB FABRICS WORN BY FEMALE MUSLIM ATHLETES

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Abstract: In general, Muslim women who play sports will wear a sports hijab that look aesthetic, easy to wear and comfortable. Nevertheless, in a hot and humid weather, they may feel clampy and unease at times. This paper reports some studies on the comfort aspects of several commercial hijab fabrics through a blind evaluation test and wear trials with certain test protocols. Respondents chosen were undergraduate students who are accustomed to wearing hijab while doing physical exercises and sporting activities. The findings revealed that the fabric consisting of polyester and spandex gave the smoothest, softest, and coolest feel from the blind evaluation test. The same fabric gave exceptionally high scores after the wear trials. The 100% cotton and 100% polyester hijab fabrics were rated as uncomfortable to wear during sporting activities. Besides the fibre type, the comfort aspects of the fabrics also very much depended on the fabric structures, parameters and properties such as air permeability and moisture management.
Keywords: Thermal comfort, Sport Hijab, Clothing, Sports Activity, Female Athletes

1. INTRODUCTION

The Muslim population has been said as among the fastest-growing group in the world [1] and thus their consumption on clothing can be said to increase as well. Women comprise of the larger fraction in the 1.6 billion of Muslims worldwide and more than half of them are hijab users [2]. Nowadays, hijabs in the market are observed to be in vast forms of modern and contemporary styles and can be found being discussed in several fashion related studies. With the vast availability, consumers tend to be selective in choosing hijab that meets their expectations and satisfactions to make worth of their purchases. Thus far, the current market is seen to be catering two main categories of hijabs which are the casual types and for sports purposes. The sport hijabs are meant for physical activity purposes or sports hijabs which have become popular among female Muslim athletes.

Generally, Muslim women athletes prefer modest sportswear to cover their physical including a hijab that covers the head and the neck region during sports activities. Despite the availability of hijab sportswear in the local market, the types of suitable material are limited compared to the larger availability of hijabs for regular uses. It can be said that most local Muslim women athletes in Malaysia are seen assuming these regular hijabs for their sport activities. Therefore, it is vital to investigate the comfort performance of hijab fabric which could help in understanding the expectations of Muslim sportswomen on hijab comfort.

At present, many hijabs related studies were conducted in social sciences. Technical research studies on Islamic apparel have not been extensively explored by many researchers. An earlier study [3] worked on the thermal comfort, post training response and fluid balance between athletes wearing Islamic themed clothing and traditional soccer uniform. Interestingly, the study revealed that Islamic based active garment did not result in negative effects on the studied parameters. In a recent study [4], the perceived thermal comfort experienced by active young Muslim women wearing hijabs was investigated. It was found that the female athletes used regular or casual hijabs for their sport activities and regular exercises which do not offer sufficient thermal comfort. In another study [5], the work focused on designing a suitable modest sportswear for women athletes wearing a hijab. Nevertheless, the study focused highly on the designing aspects, rather than the technical characteristic of textile fabrics related to thermal comfort values.

Thermophysiological comfort (or thermal comfort) correlated with the fabric weight, thickness, moisture regain, air permeability and moisture management

capacity [6]. Hence, in this study, the thermal comfort of several commercial knitted fabrics used for sport hijabs were explored using subjective evaluation and subjective wear trials.

2. MATERIALS AND METHODS

Five different knitted fabrics were selected for the study (Table 1). The fabrics were randomly chosen from commercial hijab fabrics found in the market. In the first part of the study, a subjective evaluation conducted to assessed consumer's perception towards the inner hijabs and to subjectively assess the consumer's comfort aspect of the inner hijabs. In the second part, subjective wear trials were conducted following modified protocols from a previous study. During the tests, each participant was required to perform simple activities and provide a comfort score using five-point rating scales to assess thermal, moisture and general comfort.

Table 1. Fabric details

Fabric Type	Thickness (mm)	Areal Density (g/m^2)	Air Permeability (mm/s)
100% cotton (A)	0.58	408.81	223.40
100% polyester (B)	0.52	267.71	413.80
Cotton viscose (C)	0.54	303.59	570.10
60% rayon/ 30% polyester/ 10% spandex (D)	0.48	202.65	948.30
90% polyester/ 10% spandex (E)	0.60	300.54	692.50

The subjective evaluation was done based on AATC Evaluation procedure 5-2011 using blind evaluation test. The evaluation was conducted in a laboratory with A group of participants consisting of 11 undergraduate students in the field of textile science & fashion technology were chosen. Prior to commencement of the test, all sample were labelled with respective codes and placed in the lid of boxes as shown in Figure 1. All the participants were briefed and given some demonstrations on how the test should be conducted by observations and touch methods [7]. All the

participants were blind fold and was asked to rate each samples using rating scale from 1 to 10 for Surface Warmth, Smoothness and Softness. The fabric can be grasp in many different ways. Nevertheless, a standard touch method described in a recent study [8] was employed.

In the second part of the study, modified subjective wear trials were conducted in a controlled environment room to test for wet clingy sensation following established protocols [9]. A total of five participants who usually wears sports hijab were involved in the trials. They were required to wear the hijabs at in the test room 15 minutes before each trial to acclimatize. The level of the activity was arranged by changing the speed of the treadmill (Table 2). Prior to the subjective wear trial, each participant was required to drink 400ml lukewarm water 30 minutes before the test commenced. Each trial lasted from 45 minutes to 1 hour. Each participant was required to provide a comfort score using five-point rating scales to assess thermal, moisture and general comfort in Table 3.

Figure 1. Sample preparation and placing

Table 2. Activity protocols for wear trial test (modified from [9])

Time (minutes)	Activities
0	Acclimatize 30 minutes inside the room
5	Doing sedentary work
5	Walk on treadmill at constant speed of 3 km/h
5	Rest
5	Light jog on treadmill at constant speed of 5 km/h
5	Rest (Cooling)

Table 3. Comfort score rating after activity [9]

Comfort Score	**1**	**2**	**3**	**4**	**5**
Coolness	Cold	Cool	Neutral	Warm	Hot
Dampness	Dry	Slightly dry	Moderately	Very damp	Extremely damp
Comfort	Totally uncomfortable	Slightly uncomfortable	Moderately comfortable	Very comfortable	Extremely comfortable
Sensory descriptors: 1 (I do not feel absolutely..) ….. 5 (I completely feel …)					

3. RESULTS & DISCUSSION

1. Blind Evaluation Results

The Kalmogrov-Smirnov test (p>.05) shown in Table 4 and visual inspections of histograms, normal Q-Q plots and box plots show that the attributes were approximately normal distributed. The analysis was conducted using rating system and converted into rank to be able to implement the calculations. After normalization, a reliability test was analysed to determine the consistency of the data and the degree to which the scales connect to each other. In this study, the Cronbach's alpha coefficient was used as indicators for internal consistency (Table 5). It is ideal for Cronbach's alpha coefficient to be above 7 [10]. But due to the sensitivity of number of items in the scale, low Cronbach value are found quite common with items below than 10. Therefore, it is appropriate to report the mean inter-item correlation for the items.

Table 4. Kolomogorov-Smirnov Test

	Kolmogorov-Smirnov[a]
Warmness	0.0510
Smoothness	0.0608
Softness	0.0944

Table 5. Cronbach's Alpha Test

	Cronbach's Alpha
Warmness	0.566
Smoothness	0.287
Softest	0.551

The results show that smoothness have some inconsistency in several samples evaluated by the participants. However, when those inconsistence value was eliminated, Cronbach's alpha positively increase when item deleted following the suggested item presented. At present, there is no universal minimally acceptable reliability value. The values depend on the type of applications and they both agree the focus should be on the population reliability value not the sample reliability value. In conjunction with that, much smaller reliabilities can be accepted as long as the effect size result are interpreted accordingly. Both concluded that reliability coefficient is much need to be reported together with its confidence intervals for all important parameters and required sample values of Cronbach's alpha be augmented appropriated confidence interval. After normalization and reliability test, data from the blind test method can presented in one scale. The mean and standard deviation of the samples for softness, smoothness and warmness are shown in Figures 6 - 8.

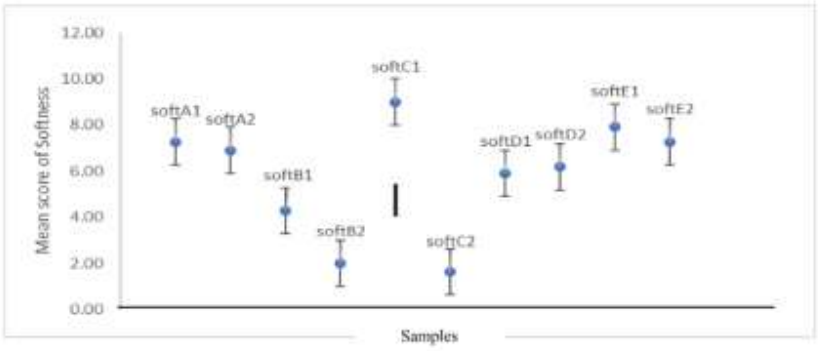

Figure 6. Mean score of for softness with error bar showing standard deviation

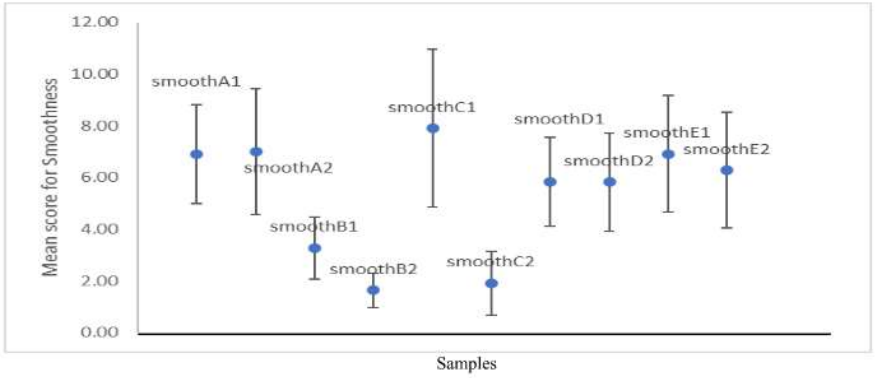

Figure 7. Mean score of for smoothness with error bar showing standard deviation

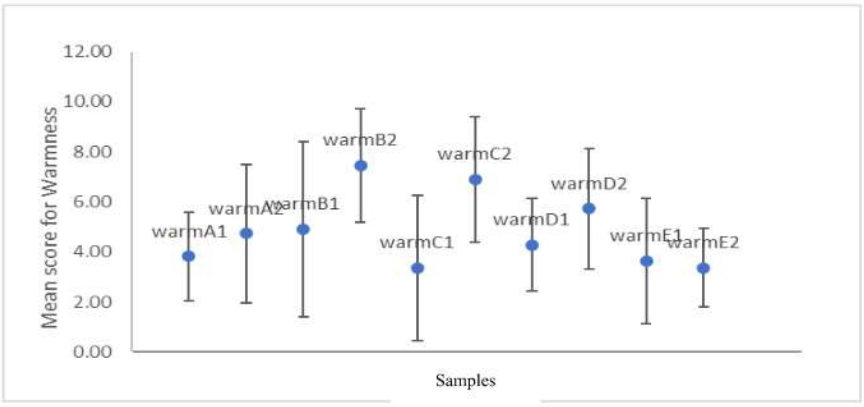

Figure 8. Mean score of for warmness with error bar showing standard deviation

Inner hijabs C1 was selected as the softest and smoothest among all inner hijabs tested and C2 and B2 are chosen as similarly the roughest and hardest among all hijab fabric evaluated. In general, the standard deviation for softness is much lower than smoothness as illustrated by the error bars in the graphs. Despite that, the values can still be considered as small which shows positive agreement on the results between the correspondents. Hijab fabric was made up of cotton spandex blend which give smoother and softer handle compare the roughest and hardest hijab fabric made up

of 100% cotton and 100% polyester respectively. This positively shows that spandex enhance the handle properties of cotton which known to be the least soft. Elasticity and stretchability of spandex properties given smoother and softer feeling. Other than that, hijab fabric E1 which made of polyester spandex come in second in term of softness as knitted fabrics are known for their bulkiness and fluffy feel when in contact with skin. However, some studies shows that wood-based cellulosic fabrics give smoother and softer handle than cotton. A wide agreement was discussed on the methods of hand assessors and observed the ranges that diverge due to the similarity of fabrics [11].

Hijab fabric B2 shows the lowest means score in both smoothness and softness as it was interpreted to be the roughest and hardest of all hijab fabric tested. Hijab fabric B2 which made up of 100% cotton rated as the least preferred. It verified the score given to hijab fabric C1 and E1 which had fair percentage of spandex blend to give more drapey, smooth and soft feel when touch.

Figure 8 show the mean score for warmness which portrayed that hijab fabric B1 is the warmest of all hijab fabric while hijab fabric C1 the coolest. High discrepancies were perceived among the correspondent which can be seen by the error bars. Warmth is measured during initial contact of the skin onto the fabric, and it was evaluated prior to the other two attributes. The contradictions between the correspondents on warmth attributes, which might be due to small differences on the thermal sensation. Studies by Tadesse et al. [12], discussed that thermal comfort is not only affected by design and construction but finishing and moisture. However, thermal was another part of the topic to clothing comfort and must not be able to correlate with the fabric hand of warmness. Thickness may also play a role in changing the thermal contact feeling of the tested fabric which makes thicker fabric feel warmer. Studies by Bartkowiak et al. [13] found that fabric with the highest content of cotton fibres give warmth feeling at touch. As the volume of yarn and its stretchiness elevate, the fabric becomes more pleasant, less synthetic in touch, softer and warmer. However, this is not applicable to hijab fabric B1 in terms of softness and smoothness.

2. Subjective Wear Trials

The comfort performance of the hijab was further analysed by the modified subjective wear trials. Subjective coolness, dampness, and comfort evaluation result were acquired before and after each test. All participants expressed their comfort status by sensory descriptors at the end of the trial sessions. The average of the five-point rating results is shown in Table 4.

Table 4. Five-point rating (average) for subjective wear trials

Fabric Type	Coolness		Dampness		Comfort	
	Before	After	Before	After	Before	After
A	3	2	1	3	4	3
B	4	3	1	2	2	1
C	2	1	1	3	4	4
D	2	1	1	1	3	4
E	1	1	1	1	5	5

The comfort ratings for hijab fabric E are oppositely distinctive from the rest of the other fabrics. The participants gave positive reactions after the trials. These results supported the claims by the participants that hijab fabric E is very light, soft, and comfortable to wear. The coolness rating for this fabric remains unchanged (indicating cold) even after the physical activities ended. Similarly, the ratings remained unchanged for dampness (dry) and comfort (extremely comfortable). Hijab fabric E significantly felt drier, and cooler compared to hijab fabric A (100% cotton) which felt warm and damped after the trials. This is due to cotton having higher moisture absorption rate and easily damped due to perspiration. Hijab fabric E also was distinctive from B (100% polyester).

As the intensity of activities increases, the coolness of fabrics A, B, C and D decreased by 1 rating from before the trials commenced. This means that the fabrics felt cooler after the trials. This may indicate sweat still remains on the fabric. The average score of coolness for hijab fabric A (100% cotton) is 2 indicating cool while the rating is neutral for B (100% polyester). Hijab fabric C, D and E rated as cold. Besides the fibre type, the properties may be due to the differences in the structural parameters such

as thickness, areal density, and structure of the fabrics that influences the fabric's porosity, tightness factor and stiffness.
Among the fabrics, hijab fabrics D and E have dampness score rating of completely dry. Hijab fabrics with cotton (A and C) are rated as moderately damped after the trials. Again, this may be due to the absorptive nature of cotton coupled with the higher areal density and lower air permeability of the fabrics. The comfort level shows the lowest point (1 for totally uncomfortable) for
B. This corresponds to the sensory descriptors of the of the hijab B where it feels rough, rigid, and tight while wearing the hijab for both condition of the trials. The polyester fabric removes the liquid sweat better than any other fabrics which explains the feeling of dryness after the physical activities.

4. CONCLUSIONS

Due to the differences in the fabric parameters of the fabrics, they differ from one another in many aspects. The fabric with polyester and spandex (E) has good air permeability and the highest overall moisture management capability. In the wear trials, the participants rated the same fabric of having high coolness, dry and very comfortable to wear as a hijab. The cotton fabric (A) was rated as rather warm and moderately damped after the physical activities. Besides the natural high absorption rate of cotton, this was added by the construction of the fabric and higher areal density which gave less porosity to elevate heat out to the environment. It is also interesting to note that in the wear trials, the participants rated the 100% polyester fabric (B) as giving moderate coolness and uncomfortable to wear.

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management and analysis; Aznin Baharudin, Nur Syazleen Zamri, and Nurul Sarah Aliah Mat Adini are postgraduate students who performed the experiments.

Conflicts of Interest: The authors declare no conflict of interest.

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