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خصائص الراحة في ملابس الحج والعمرة (الإحرام)

Comfort properties of Hajj and Umrah Clothes (Ihram)

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ملابس الإحرام، الأشعة فوق البنفسجية، الخصائص الفيزيقية، خصائص الراحة، الإشعاع، النسيج ihram clothing, UV rays, physical properties, comfort properties, radiation, texture	28 March 2023	21 June 2023	December 2023

الملخص

اختص الله تعالى المسلمين بأداء فريضة الحج والعمرة ويرتدى الرجال أثناء أداء المناسك ما يسمى ب(الإحرام)، وهو رداء غير مخيط مكون من قطعتين من القماش (الإزارَ والرداء) ويتوفر بأنواع مختلفة من المنسوجات. ونتيجة للظروف المناخية والبيئية في مكة المكرمة والتي تشهد أداء المناسك، فهناك العديد من الخصائص التي يجب توفرها في هذا القماش مثل خصائص الراحة ويهدف البحث الى اختبار خصائص نفاذية الهواء ونفاذية بخار الماء ونسبة الرطوبة. بالإضافة الى قياس تأثير الأشعة فوق البنفسجية من الشمس على أداء هذه الملابس وتم اختيار ملابس الإحرام الأكثر انتشاراً في السوق المحلي واتبع البحث المنهج الوصفي التحليلي وتتضح أهمية البحث في القاء الضوء على خصائص الأقمشة المستخدمة في الإحرام تبعاً للظروف المناخية في مكة المكرمة وذلك في ضوء رؤية 2030والتي تسعى الى زيادة عدد الحجاج والمعتمرين وتوفير المناخ المناسب، وتم التوصل الى أن الأشعة فوق البنفسجية لها تأثير كبير على خصائص الراحة لهذه الملابس

Abstract

Allah singled out Muslims to perform Hajj and Umrah. Men are required to wear what is referred to as an ihram which consists of two unstitched pieces of fabric called: izar and ridaa. There are various types of ihram fabrics available. As a result of the climatic and environmental conditions in Makkah, there are many characteristics that must be present in the type of cloth used: such as, comfort properties. The research aims to test the properties of air permeability, water vapor permeability, and humidity while measuring the effect of ultraviolet radiation from the sun on the performance of these clothes. The most prevalent ihram clothing on the market was selected. The research follows the analytical descriptive approach. The objective of the research is to shed light on the characteristics of the fabrics used, while in the state of ihram, in the climate conditions of Makkah. In light of Vision 2030, which seeks to increase the number of pilgrims while providing the appropriate conditions, it was discovered that UV has a significant impact on the drape and comfort properties of this clothing.

Introduction

Every year, millions of Muslims perform a religious pilgrimage to Makkah, Saudi Arabia. Any improvement in the design, comfort, or functionality of the clothing worn by pilgrims, would prove to be beneficial by bringing about their comfort. The ihram is made out of soft woven cotton fabric, (rings appear on one or both sides of the cloth) and is always white, consisting of two unstitched pieces of fabric. The first piece of material, which covers the lower part of the body, (from the navel to the knee) is called izar, and the second piece (which covers the upper portion) is called: ridaa. The

Ihram is worn directly against the body without any other layers of clothing. It is wrapped around the body, and fixed in place by a belt. More research related to comfort and durability needs to be done in regard to ihram fabric, especially, thermo-physiological comfort and lifespan of the clothing. The purpose of conducting this research is to see the effect that the material, ambient conditions, and comfort level have on those wearing this type of garment. Objective analysis is very important in analyzing the overall performance of this type of clothing. Textile garments not only serve as an obstacle to external atmosphere, but also work as a channel of heat loss from the body into the atmosphere (Holmer, 2008),(Luo, 2018). There are three major modes of heat transfer: conduction, convection, and radiation, (Haghi, 2011), (Morrisey, 2014), (Kalaoglu, 2022)

Equation 1

Rate of heat flow by conductivity

(1) $$\dot{Q} = \frac{KAdT}{x}$$

In which,Q is the rate of heat flow (W or J/sec), A is the area (m2), K is thermal conductivity [W/(m.K)], dT is difference of temperature, and x shows the dimensions of the material.

The second major source of heat transfer is convection, in which a fluid is required for the heat to be transferred. In textile, either the forced flow of air, or natural convection causes heat transfer (Choudary, 2011),(Enescu, 2017). This can be expressed as:

Equation 2

(2) $$Q = h_c a \Delta T$$

Where "a" is the surface area of the heated object, h_c is the coefficient of convective heat transfer, and ΔT is temperature difference. The third medium of heat transfer is by radiation, which can be expressed by the following well known equation (Kalaoglu, 2022):

Equation 3

(3) $$Q = A\ \varepsilon\sigma P^4$$

Where Ɛ is emissivity of the object, and Q is Stefen Boltzman constant: the value is 5.67 x 10-8 W/m2K4, P is body temperature, and A is the surface area.

Theoretical Framework

Mechanism of thermal equilibrium of human body

Equation 4

Summary of heat balance in the human body (Enescu, 2017):

(4) $$M - W = C_{conv} + C_{cond} + R + E_s + E_{resp} + C_{resp}$$

M = Body heat W/m2)

W= Outward work done (W/m2)

C_conv= Thermal loss due to convection

C_cond= Heat lost due to conductivity (W/m2)

R= Heat lost by radiation (W/m2)

E_s= Heat lost by perspiration and evaporation of sweat (W/m2)

E_resp= Evaporative thermal loss by breathing (W/m2)

C_resp= Sensible breathing loss (W/m2)

The human body generates heat, constantly, and the rate of metabolism is always positive. At the same time, there are major sources of heat loss, and they all work to keep a person in a state of comfort. Multiple factors, like: external conditions, activity level, and overall clothing make a person naturally fit into the environment. A naked person, at normal room temperature, gives off the majority of their body heat by means of radiation. As external radiation hits the body, the following possibilities can occur:

Radiation heat is transmitted without affecting the individual

The radiation path is deflected or reflected

Radiation heat is absorbed

The mean radiation temperature (MRT) defines heat which is lost or gained, on an unclothed human body, with respect to the heat gradient of the environment (Ravandi,

2011).

In the case of two-dimensional zones, MRT can be evaluated as:

Equation 5

(5) $$MRT = \frac{\Sigma T\theta}{360} = \frac{T_1\theta_1 + T_2\theta_2 + T_3\theta_3 + \cdots T_n\theta_n}{360}$$

In equation 5, T is surface temperature, while θ is measured in degrees, and is the angle of exposure of the surface, with respect to the incumbents. In the absence of air flow (Fronczak, 2011), thermal radiation is the only mode of heat transfer involving the body and the surrounding climate (Narayan, 2010.)

Clothing Comfort

It is complicated to define what exactly accounts for clothing comfort, but from the literature, comfort can be explained as:

i Psychological comfort: which can be summarized as retaining functionality without foreign intervention

ii Physiological comfort: which is connected to how the body actually feels

iii Physical comfort: which is connected to ambient conditions

Clothing plays a significant role in the connection of the atmosphere, with the body. Some contributing factors are:

- Temperature
- Humidity
- Air flow (Ogulata, 2017).
- Demographics

- Activity level (Reng, 2019).

Comfortable clothing has many benefits, such as:

- Increased productivity
- Fewer errors
- Fewer accidents
- Healthier body (Tedese, 2021), (Zhu, 2021).

The amount of comfort experienced through wearing clothing is greatly influenced by the amount of heat and moisture that can be transferred from the textile layers, and the protection from heat and radiation from the outer source. Clothing comfort cannot be defined in the same manner, in different countries, having different ambient conditions.

The effect of UV on materials

Textile materials are significantly impacted by photo degradation, primarily UV from sunlight. The impact is seen more in countries with longer days, days consisting of more than eight hours of sunlight, regularly (Enescu, 2017). Textile materials, either natural or polymeric, lose strength, colour, and functional properties (Reng, 2019). This effect cannot be ignored, since garment durability is very important, and UV decreases clothing lifespan, significantly. There are two types of weathering:

- Real conditions (natural)
- Accelerated weathering (Artificial)

Natural Weathering

In this type of weathering, the sample is placed at a 150 angle, facing sunlight, and the sample is placed there for a specified period of time, depending on the region (Europe,

Middle East, America etc.). Secondly, ambient conditions also play an important role in the weathering process. A process called accelerated natural weathering occurs when a sample is placed in natural sunlight, in more extreme regions of the world, in order to obtain a faster impact.

Artificial lab weathering

Different machines are available for UV weathering of material and for textile. The most common machine is from ATLAS which uses UVA, B, and C and works according to the standard DIN EN 12224. One week of accelerated weathering by this machine is equal to six months of natural UV exposure. This way, the impact on textile materials can be recorded more quickly.

The main objectives of the research are:

1- To measure water vapour permeability of ihram clothing

2- To analyze the mechanical drape of ihram clothing after UV exposure

3- To determine the thermo-physiological comfort (breathability) of ihram clothing before and after UV

Research Methodology

The research follows the descriptive approach in analyzing the properties of fabrics used to make ihram clothing. In addition, the semi-experimental approach was incorporated in laboratory experiments conducted on the fabrics used in the study.

Research terms

Ihram is a type of clothing worn by Muslims during the performance of Hajj and Umrah, and it is an essential part of performing the rituals. It consists of two pieces of unstitched fabric that are wrapped around the body, the first piece, called izar, covers

the lower part of the body (from the navel to the knee), and the second piece, called ridaa, covers the back and is inserted under the right armpit and draped over the left shoulder. It is desirable for the ihram to be white. (Debes, 2021).

Mechanical performance

The Drape of the ihram fabric is very important, and it is measured by standard BS EN 9073. The drape of the material can be impacted by UV weathering and can cause discomfort to the wearer.

Air permeability

Air permeability is very important for those wearing an ihram in extreme heat conditions. To measure air permeability, the standard device is an air permeability tester from ATLAS FX3300, standard ISO 9230. Samples are tested before and after UV exposure to compare the impact of sunlight on the material.

Experimental part

The most common ihram fabric used is either cotton-towel, or cotton-woven. The reason for this is that it generally has a better feeling next to the skin, and has a higher amount of moisture absorbency from the natural fibers. In winter, a thick towel fabric is used; and in summer, a thin woven cotton fabric is used. For this research, the six most common ihram fabrics were used; three were towel material (made from 100% cotton), and the remaining three were plain, woven, 100% cotton fabrics. All fabrics were bought according to the preferences of customers, and are the most commonly used fabrics by international pilgrims. The textile material is tested for the following properties both before and after UV degradation:

1- Air permeability by standard ISO 9230

2- Water vapor permeability by standard ISO11092 (using sweating guarded hot plate)

3- Drape testing by standard BS EN 9073

4- UV degradation by ATLAS UV2000 (ISO 11507)

Table 1 Ihram woven fabric composition

Fabric	A	B	C
Composition	100% Cotton	100% Cotton	100% Cotton
Construction	Twill	Satin	Plain
Thickness [mm]	2.2(±0.14)	2.18(±0.18)	1.99 (±0.11)
Fabric Mass [g/m2]	230	238	190

All samples are in pure white, varying shades are due to photo capturing variation

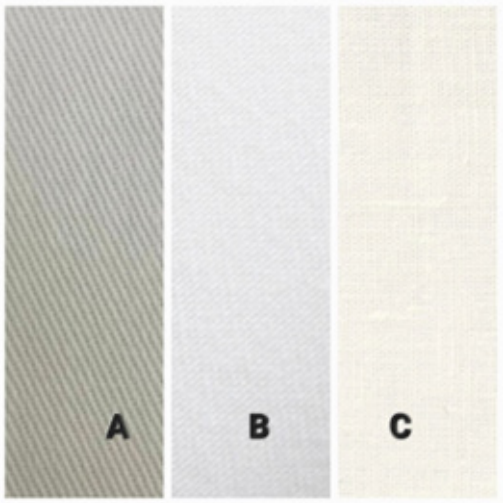

Figure 1. Woven fabrics

Table 2. Ihram fabric (towel, terry woven)

Fabric	D	F	F
Composition	100% Cotton	100% Cotton	100% Cotton
Construction	Terry Towels	Terry Towels	Terry Towels
Thickness [mm]	10.2(±1.12)	9.8(±1.2)	8.5(±1.15)
Fabric Mass [g/m2]	330	260	240

Figure 2. Towel samples, all samples are pure white

The fabrics are tested for air permeability, water vapor permeability, and drape testing before and after UV degradation. The UV degradation of six days was applied without the rain factor. This is equivalent to six months of natural degradation by the sun. The samples were conditioned for 24 hours, in the climate room, with 60% R.H and at 23oC. Later, the samples were placed in the UV chamber of the Atlas weathering machine (according to the standard DIN EN12224).

Methodology

Three woven fabric samples (A,B,C) and three towel fabric samples (D, E,F) are tested for drape, air permeability, water vapour resistance, and finally, all samples are weathered by UV weathering setup. All tests are repeated for experimental comparison.

Results & Discussion

A seven day test of continuous UV exposure is performed. This is a quick way to obtain samples which would normally take six months of exposure to the heat of the midday sun, to be naturally weathered. In this way, 36 samples consisting of both towel and woven fabrics (6 testing samples of each fabric) are obtained with UV exposure.

These samples will further be used to compare results related to drape, air permeability, and water vapour permeability. Drape testing, according to standard BS EN 9073, shows resistance of textile materials to bending.

Results of drape testing

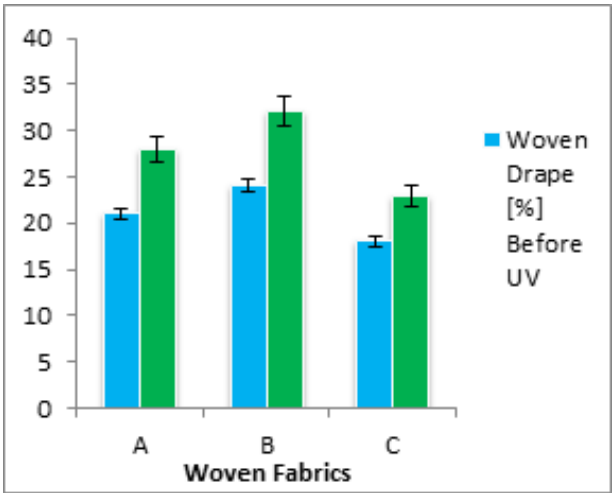

Figure 3: Woven fabric drape coefficent change after UV

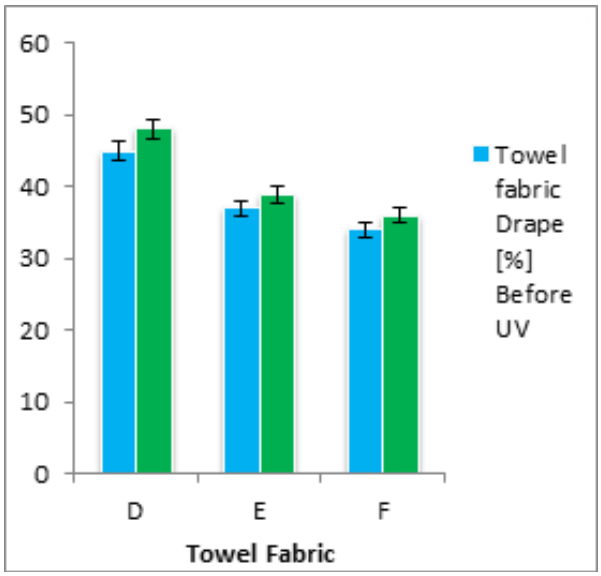

Figure 4: Towel fabric drape coefficent change after UV

It can be seen in the graphs that both the woven, and towel fabrics, are significantly impacted by UV weathering. The effect is more dominant for thin fabric and woven fabric, which could be due to the fact that towel fabric is fluffier, making it difficult for UV light to impact the core of the fabric. On the other hand, the woven fabric (A, B, C) has fewer protruding fibers, and a densely packed structure, which causes a higher exposure to UV, and also causes the drape coefficient to be much higher. The higher percentage of drape coefficient shows that the material is stiffer. The samples are further tested for air permeability according to standard ISO 923, on device FX3300. The results are tested before and after UV exposure.

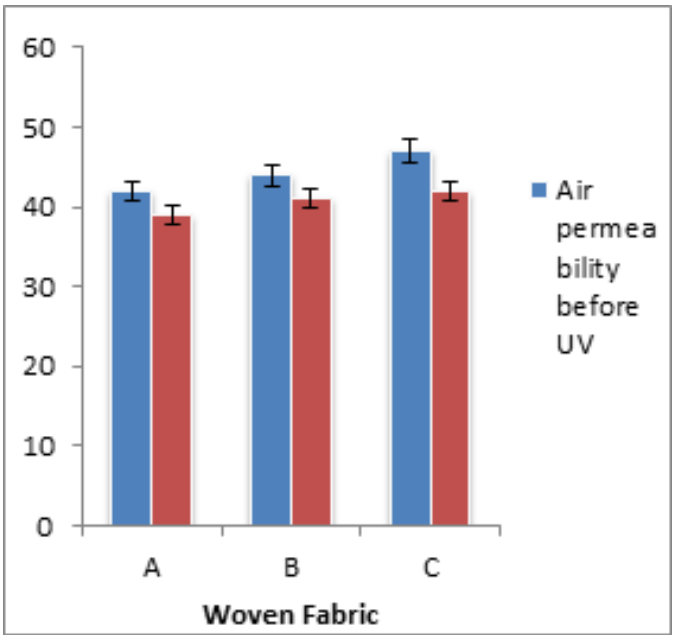

Figure 5. Air permeability of woven fabric

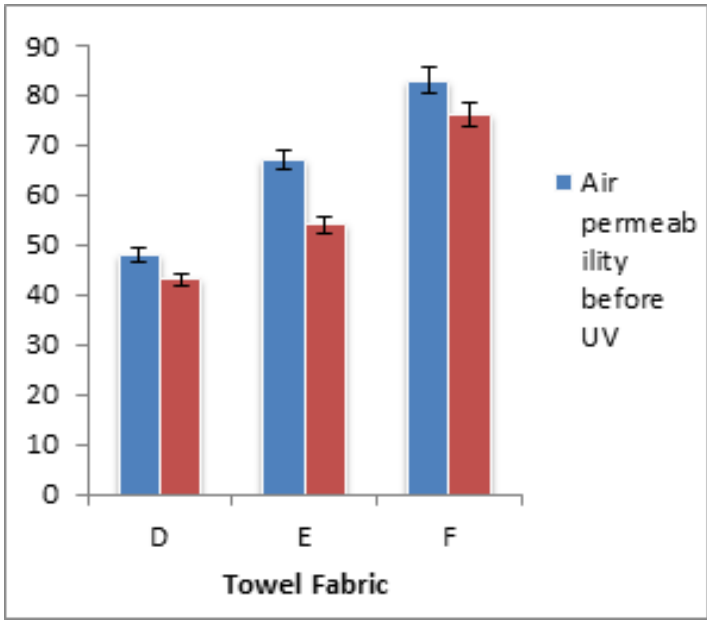

Figure 6. Air permeability of towel fabric

The towel fabric has higher air permeability when compared to the woven fabric, (see figures 5 & 6) even though, the towel fabric has a higher GSM and thickness compared to the woven fabric. The air permeability is mainly dependent on pore size and overall channel throughout the fabric. In general, the towel fabrics are more permeable when compared to the woven fabrics, however, after UV exposure, the woven fabric shows a slight decrease in air permeability which might be due to a less fibrous structure and a denser weave. In contrast, the fluffy structure of the towel fabric is significantly impacted by UV and shows a decrease of air permeability, much higher than woven fabrics. Finally, the water vapour permeability is measured on the sweating guarded hot plate and the results are tested before and after UV exposure. The water vapor resistance is very important for clothing since a wet microclimate, in general, is considered uncomfortable. The results are shown in figures 7 and 8.

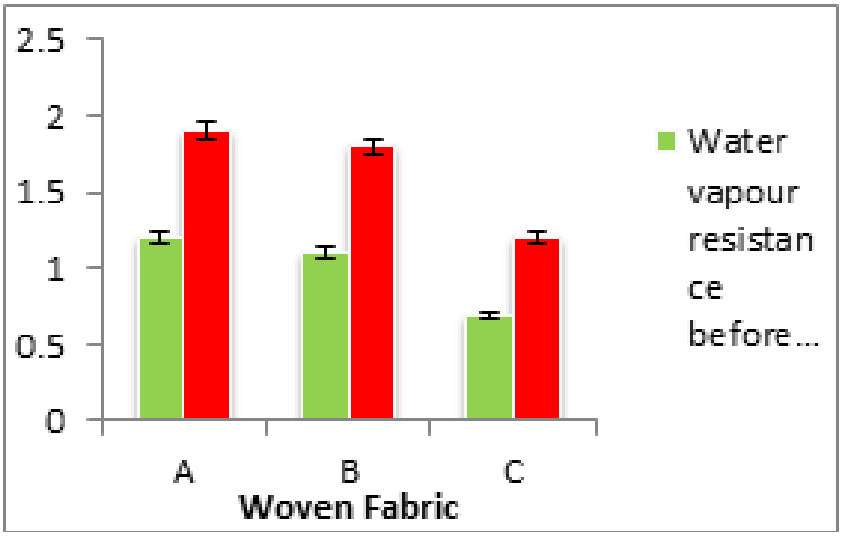

Figure 7. Water vapor resistance of woven fabric

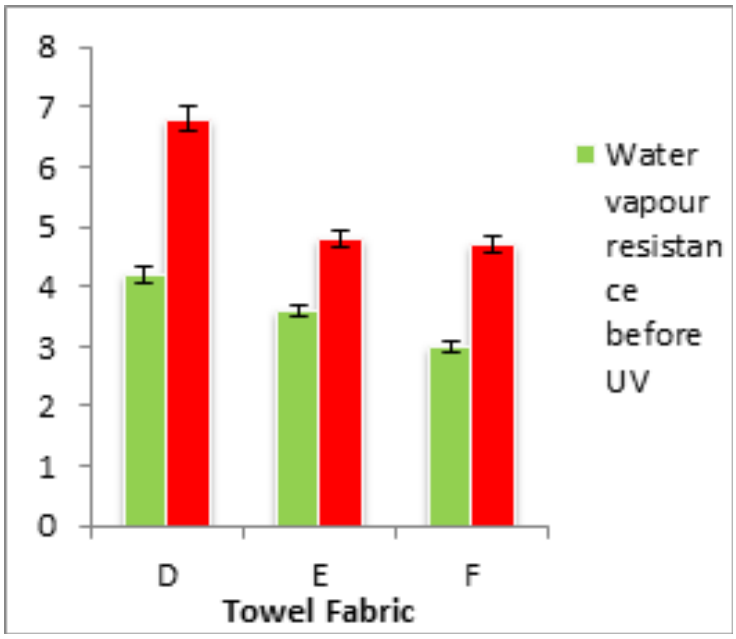

Figure 8. Water vapor resistance of towel fabric

The water vapor resistance of towel fabric is much higher than that of woven fabric. This is mainly due to the woven fabric being thinner, and having a low GSM, however, after UV exposure both the woven and towel fabrics were significatly impacted by the

weathering. The channel required for the water vapor to pass might be damaged by the UV weathering, and this is a very important factor for the comfort of the clothing, and UV weathering significatly decreases these properties.

Conclusion

It can be concluded from the research that UV weathering significantly impacts the comfort properties of ihram fabrics. In general, woven fabrics have a better drape, higher water vapour permeability, and are significantly impacted by UV weathering. On the other hand, towel fabrics have higher air permeability, with a poor drape, and are also damaged by UV weathering, but at a lesser degree when compared to woven fabric. This might be due to the fluffy nature of the towel fabric. It can be summarized that comfort properties are impacted by UV, and suitable materials can be chosen according to the ambient condition, like wearing higher GSM fabric, such as towel, in the winter, and wearing lower GSM fabric, such as woven, in the summer. Fabrics are impacted by UV, so it should be kept in mind that properties decrease with exposure to sunlight. The research can be further extended to polymeric materials, but due to their higher moisture content and comfort experienced against the skin: cotton is the most preferred material for ihram.

Recommendations

In general, plain fabrics and materials with the lowest amount of thickness, tended to show the best comfort properties. On the other hand, the less protruding fibers caused more damage to the material in terms of mechanical properties. It is difficult to recommend any particular ihram based on the UV weathering due to the fact that: thickness of material, type of woven strucure, and overall feel of the fabric make the

selection process a very personal choice. From this research, it is obvious that there is a significant impact on the mechanical properties of all types of ihram, under sunlight. There have only been a few previous studies on UV weathering of pilgrimage clothes, but multiple articles are available related to the comfort level of this particular type of clothing. Further studies could be done to connect comfort with weathering, durability, and lifetime of these garments.

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