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The Physiological Response on Wear Comfort of Polyethylene Terephthalate Irradiated by Ultra-violet

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Abstract: The purpose of this study was to evaluate the comfort of PET clothing treated by UV. The physiological responses of the human body were investigated. Mean skin temperature and physiological signals such as Electroencephalogram (EEG), and heart rate (Electrocardiogram, (ECG)) were examined for 20 minutes during stable wearing conditions. Mean skin temperature was measured every two seconds using Ramanathan's method. Physiological responses were measured using Biopac MP100 series and analyzed using the software, Acqknowledge 3.5.2. Psychological effects were analyzed every five minutes. Comfort of untreated PET clothing decreased with the passage of time. Compared with PET clothing untreated, treated for 30 minutes, and treated for 90 minutes, the analysis of EEG showed that PET clothing treated for 90 minutes was the most comfortable after 20 minutes. In addition, the interval of the heart rate shown on the ECG was the highest in PET clothing treated for 90 minutes. Skin temperature was the lowest in PET treated for 90 minutes. We thus conclude that suitable UV irradiation would improve comfort.

Keywords: Physiological responses, Wear comfort, UV treatment

Introduction

Because consumer's requirements vary, it is important to investigate psychological aspects such as 'comfort' and 'preference' as well as function to determine the value of fabrics. Therefore, consumer's sensitivity to these aspects was considered in developing the fabric. However, it is difficult to measure human sensitivity, because it changes relatively and immediately to information and to changes in time. In addition, this individuality makes it hard to evaluate with standard methods. Human emotion through the autonomic nervous system evokes physical changes to the internal organs and endocrine system. Methods for measuring human emotion have included subjective evaluation using questionnaires, as well as objective measurements of physiological signals produced by an external stimulus. The descriptors used for subjective evaluation might be understood differently by each person or the psychological state of a person. However, physiological responses mainly controlled by the autonomic nervous system are difficult to change on purpose. Therefore, physiological responses can be used as objective indices of human sensation. Currently, researchers generally measure physiological responses using the electroencephalogram(EEG), electrocardiogram(ECG), Galvanic Skin Resistance(GSR) or skin temperature(SKT) to quantify human sensation in a more accurate and objective way. Accordingly, the objective measurements were needed to get consistency in measuring human emotion and sensitivity [1,2].

In this study, the physiological responses of the human body wearing clothing made of fabric, treated by UV in a previous study, were measured. The 4-channel PET knit fabric [3] used in this study, is used generally in sport and leisurewear. This fabric has a clover-like cross section with 4 leaves, making it possible to pull sweat away from the body to the outer layer of the fabric by the capillary effect. However, the fabric still has a poor absorption property, which is related to the hydrophobic property, poor dyeability, low hygroscopicity, and high static charge. To solve these kinds of problems, previous studies investigated the hydrophilic properties of 4-channel PET knit fabric, which was treated by UV radiation [4,5]. UV irradiation is one of the simplest surface modification methods, which adds new functions to a fabric in a dry environment. Therefore, this method is considered one of the most important surface modifications [6].

In the previous study [7], subjects evaluated clothing treated by UV irradiation for three different times. Conditions of the evaluation were walking at the speed of 6.7 km/h for 15minutes in an environment of 29 °C, 70 ± 5 % R.H. The results indicated that clothing treated by UV for 90 minutes, scored the lowest on thermal and humid sensation and absorbed sweat the fastest. In addition, this fabric scored the best on touch, total sensation, and comfort.

The purpose of this study was to evaluate the physiological responses evoked by the increase of hydrophilic properties of PET knit fabric treated by UV, measured by EEG, ECG, and SKT, in an effort to develop a fabric having both functionality and sensitivity.

Experimental

Clothing

The clothing was made as shown in Figure 1. Sport shirts were made using a fabric irradiated by UV for the times listed in Table 1.

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Table 1. Characteristics of fabric

Specimen*	Weight (g/m)	Thickness (mm)	Moisture regain (%)	Wicking (cm/10 min)	Surface energy (erg/cm^2)	Irradiation time** (min)
A	15.0915	0.952	0.4251	6	0.0028	0
B	15.0745	0.928	0.6218	16.5	0.29	30
C	15.6450	0.898	0.7047	10.6	0.6	90

*4-channel PET knit fabric, Aerocool (Hyosung, Korea), **UV instrument was manufactured in our previous study.

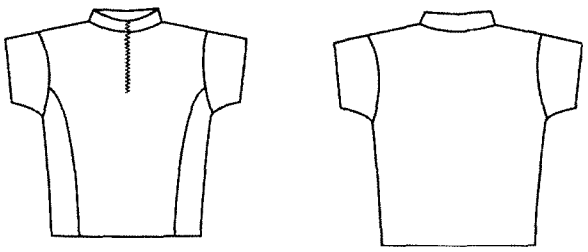

Figure 1. Design of garment for experiment.

Subjects

Subjects were 5 healthy female students whose ages ranged from 20 years to 25 years. They were asked to not smoke, drink caffeine, use drugs, or drink alcohol, all of which could influence the central and autonomic nervous system, prior to the experiment. Subjects of this study did not participate in the previous study.

Test Conditions & Process

Each subject wore the test suit and training short pant with 100 % cotton in conditions of 29 °C, 70 ± 5 % R.H. Three different, physiological signals were measured, after subjects took a rest for 10 minutes in the controlled chamber. Measurements were taken twice.

Physiological Responses and Analysis

Objectivity on the sensitivity data of clothing treated by UV was added by performing an EEG, ECG, and measuring the skin temperature. A Biopac MP 100 series was used for the measuring, and Acqknowledge 3.5.2 was used for the analysis. The signal was measured for 20 minutes. In accordance with the 10-20 electrode system, the electrodes for the EEG test were attached to the frontal lobe (Fz), and an electrode for reference was attached on the left earlobe. For processing the EEG, data was digitized (A/D transformation), and then low-pass filtering was used at a cut-off frequency of 30. Frequency analysis was done using an FFT (Fast Fourier Transformation): for signals from Fz 1(left brain) and Fz 2 (right brain), the parameters of α/total, β/total, δ/total and θ/total were calculated. For measuring the responses of the physiological signal, ECG was measured in 1 channel. For the ECG, heart rate variability was calculated using a method of zero crossing with first order differentiation, a procedure that could show an increase at the R points. The averaged R-R intervals for each 5 were calculated from the extracted R points. Physiological signals were analyzed by using MATLAB 5.3 at 5-minute intervals (a, b, c, d) shown in Figure 2. Skin temperature was measured at 2-second intervals and calculated using Ramanathan formula.

Results and Discussion

Electroencephalogram (EEG)

Figure 3 shows the differences in the EEG for physiological responses. The rhythmicity of the EEG signals provides a means for quantitatively describing EEG records, because the frequency of rhythm can be measured. EEG frequencies are conveniently classified into the following ranges or bands: the parameters of α/total, β/total, δ/total, θ/total. The α wave band width was set at 8 Hz to 13 Hz the β wave, at 13 Hz to 30 Hz the δ wave, at 1 the θ wave at 4 Hz and the wave total, at 130. Alpha rhythm in the range 8-13 Hz presents most markedly when the eyes are closed, and attenuated during attention, especially visual [8,9]. There are specific relationships between emotional changes and EEG responses evoked by tactile stimulation [10].

As shown in Figure 3, alpha wave decreased over time, for wearing the clothing untreated. This means that discomfort was increased as time passed in the summer environment of 29 °C, 70 ± 5 % R.H. The alpha wave was different with the three different clothes and the four different terms. The value

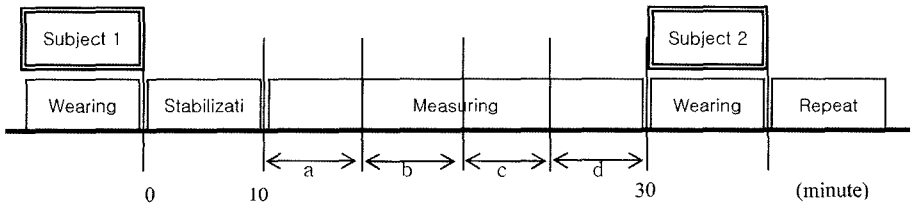

Figure 2. Time schedule of experiment.

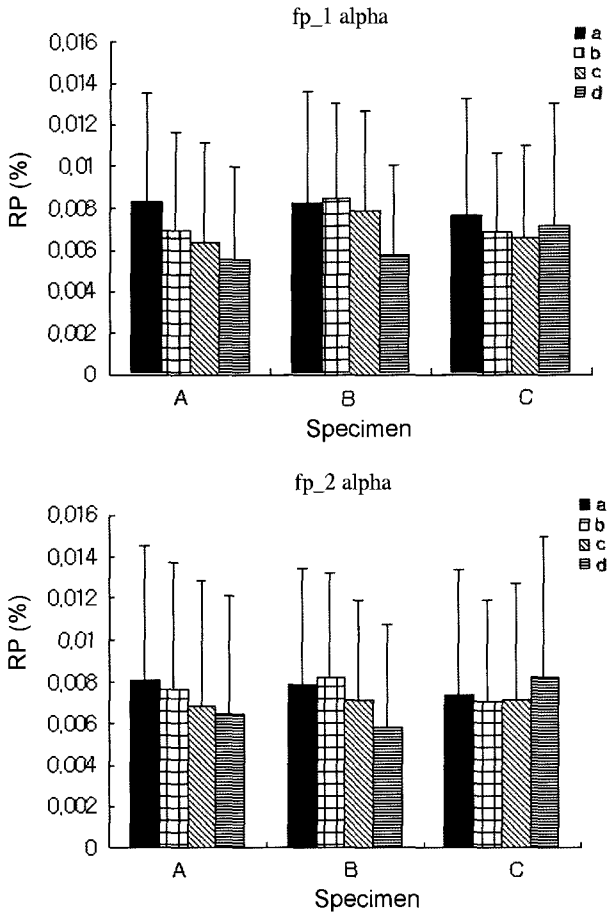

Figure 3. The value of α/total.

Table 2. Difference of alpha wave on physiological responses (%)

Specimen \ Period	a	b	c	d
A	0.826	0.689	0.627	0.546
B	0.817	0.844	0.786	0.575
C	0.766	0.682	0.651	0.708

of α/total showed the lowest decrease rate, for wearing the clothing treated by UV for 90 minutes in terms of 'd'. These findings mean that UV treatment evoked a positive sensation because of increasing hydrophilic properties and positive tactile sensation [11].

Electrocardiogram (ECG)

Heart Rate variability (HRV) is the value of quantitative heart rate, which was controlled by the autonomic nervous system to keep homeostasis. HRV is a record of responses of the autonomic nervous system. Therefore, HRV indicates a mental condition [8]. The level of average R-R interval increased with an increase in the stability level. As shown in Figure 4, we can conclude unpleasant conditions were

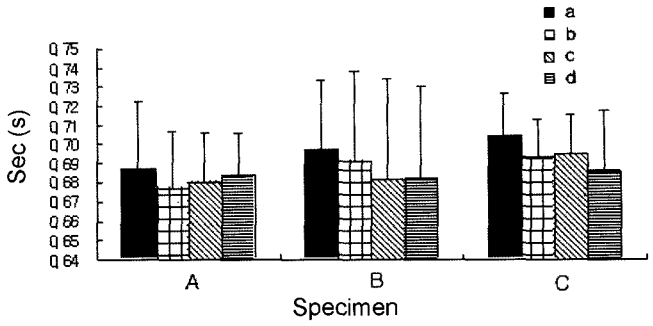

Figure 4. The averaged R-R interval.

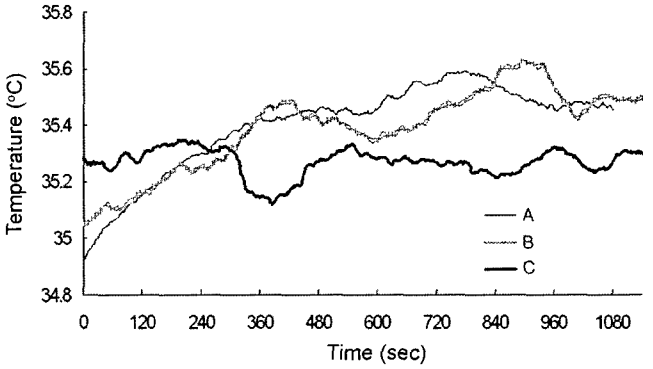

Figure 5. The skin temperature.

produced from the decrease of R-R interval with the passage of time. The averaged R-R interval decreased more for wearing irradiated 0 and 30 minutes than for wearing irradiated 90 minutes.

Skin Temperature

The result of measuring skin temperature was lower wearing clothing treated by UV for 90 minutes than wearing clothing untreated and treated by UV for 30 minutes.

Conclusion

The purpose of the study was to measure and analyze objectively and quantitatively the wear comfort and sensibility of clothes made with PET fabric treated by UV for 0, 30 minutes and 90 minutes. To investigate comfort, the physiological responses were evaluated under the actual summer environment of 29 °C, 70 ± 5 % R.H. In addition, EEG, ECG, and skin-temperature were measured to add objectivity to the sensibility tests.

The value of α/total showed the lowest decrease rate in wearing cloth treated by UV for 90 minutes. The ECG showed the biggest R-R interval and skin temperature showed the lowest interval in the cloth treated by UV for 90 minutes. The results of this physiological response correspond with the subjective evaluation of our previous study, which showed

that the value of tactile and comfort sensation was the highest for clothing made of fabric treated by UV for 90 minutes. We therefore, concluded that wearing clothing made from fabric treated by UV for 90 minutes rather than 30 minutes or untreated, was the most comfortable. We also confirmed that the results of physiological response are useful to evaluate subtle sense in developing highly sensitive and functional products.

References

1. B. C. Min, S. C. Chung, E. J. Sung, H. J. Jeon, and C. J. Kim, *Korean Journal of the Science of Emotion and Sensibility*, **4**, 23 (2001).
2. G. S. Cho, C. J. Kim, J. Y. Cho, and J. Y. Ha, *Fibers and Polymers*, **6**, 89 (2005).
3. www.textile.hyosung.co.kr/kor/products/fabric_aerocool.html, 2003-04-25.
4. H. Y. Choi and J. S. Lee, *J. Korean Soc. Clothing Textiles*, **29**, 561 (2005).
5. H. Y. Choi and J. S. Lee, *J. Korean Soc. Clothing Textiles*, **29**, 617 (2005).
6. B. K. Park, "Surface Modification of Fabric Polymer", The Korea Dyeing Technology Center, 2003.
7. H. Y. Choi and J. S. Lee, *Korea Living Science Association*, **15**, 275 (2006).
8. C. J. Kim, B. C. Min, M. C. Whang, K. S. Kim, H. J. Yang, and S. H. Oh, "Development of Synthetic Physiology Signal Measuring and Analyzing System", Korea Research Institute of Standards and Science, 1998.
9. R. Cooper, J. W. Osselton, and J. C. Shaw, "EEG Technology", Butterworths & Co., Ltd., 1980.
10. J. E. Kim, Y. S. Park, A. R. Oh, S. S. Choi, and J. H. Sohn, *Korean Journal of the Science of Emotion and Sensibility*, **1**, 153 (1998).
11. H. Y. Choi and J. S. Lee, *Fibers and Polymers*, **7**, 442 (2006).