Textile Research Journal | Article

The Precursory Analysis of the Influence of Garments on Corona Discharge Created Around a Human Fingertip

Izabela L. Ciesielska[1]
The Institute of Architecture of Textiles, The Faculty of Materials Technology and Pattern Designing, The Technical University of Lodz, 90-942 Lodz, Poland

Abstract The aim of the experiment was to analyze the corona discharge films (CDF) taken from fingertips of human subjects who had contact for a long period of time with two sets of clothes, and find out in what way a long period of contact with textiles influences life's parameters: heart beat, blood pressure, and volunteers' level of comfort. Three volunteers took part in the experiments. They placed a fingertip in the area of a strong electrical field of high voltage (10 kV) and high frequency (1024 Hz) to register a CDF. A digital camera placed within the area of corona discharges recorded this phenomenon. The analysis showed that there were no statistical differences between parameters of CDF taken from fingertips of volunteers after five hours of wearing two sets of clothes.

Key words comfort of clothes' use, corona discharge, influence of textiles on human

This experiment focused on the question whether clothes used by human subjects may influence their comfort in a measurable way.

It is already well known that clothes may impact humans, e.g. from an air permeability point of view [1–3]. Moreover, people's psychological comfort may change after change of garment, e.g. from a tracksuit for an evening dress some may change their comfort. There are many people who after coming back from work wear so-called 'home clothes'. Wearing them gives a feeling of relief, and they may help in 'regeneration' after work. Is it possible to measure such feelings? The aspects mentioned above refer to physiology and psychology of organisms in textiles.

From the literature review carried out for this research, it should be pointed out that the analysis of garments' comfort generally concerns the physiological comfort, and very rarely concerns all aspects of all kinds of comfort. This is probably connected to the lack of interdisciplinary scientific research on esthetical, psychological, thermal and physiological (thermophysiological) comfort. Answering both questions about what constitutes comfort in general as well as the feelings connected with usage of textiles is complex and difficult. The simplest way of analyzing the matter of consumers' behavior is to judge garments' preferences, and carry out marketing analysis which focuses on receiving straight responses from consumers of the product [4], e.g. does this product fulfill your expectations? A few simple questions like that may not reveal the complexity of the issue concerning fulfilling all the functions by the product with providing a satisfaction to the user, which can be understood as a thermophysiological wear comfort, skin sensorial wear comfort, psychological wear comfort connected closely with esthetical comfort, and maybe even social and finally ergonomic wear comfort.

A certain way of comfort estimation was created to broaden the analyzed issues. It takes into consideration the

[1] Corresponding author: The Institute of Architecture of Textiles, The Faculty of Materials Technology and Pattern Designing, The Technical University of Lodz, Zeromskiego Street 116, 90-942 Lodz, Poland. e-mail: Iza.Ciesielska@poczta.fm

analysis of the preferences and the skin sensorial wear comfort (smoothness of the textile material, fabric sensation in different environmental conditions), as well as electrostatic abilities of textiles surfaces, measuring the physiological parameters of the user. The most often analyzed parameters are: the temperature and humidity of the microclimate between the users' skin and the garment they wear; the frequency of muscle contraction while both resting and during physical effort; the basic physiological life parameters of textile users like heart beat (HB), blood pressure (BP) and rectal temperature [5, 6]. This kind of research develops and helps better understand the issue of comfort pertaining to different kinds of garments.

Let us analyze a sportswear as an example. The wear comfort of sportswear is an important quality criterion. It affects not only the well-being of the wearers, but also their efficiency and performance. If an active sportsperson wears sports clothes with poor air permeability and breathability, rectal temperature and HB may increase much more rapidly than while wearing breathable sportswear [7, 8]. As a consequence, the wearers of the breathable clothing outperform other athletes because they can withstand high activity levels for a longer period of time.

Another approach to textiles' comfort was proposed by American scientists [9]. They proposed to judge what external conditions allow easier acceptance of chosen textiles. The research focused on the influence of skin friction by textiles on the total feeling of comfort. It was proven that when the skin wetness and, consequently, the pressure of textiles on skin rose, the subject considered those textiles less pleasant and rougher. This decreased the total acceptance for the textile. These feelings against the skin were not noted in normal conditions. It was concluded that the higher skin wetness increased the skin friction on textiles and the feeling of roughness. As a result, lack of acceptance for the tested textiles increased.

The area where textiles come in contact with the skin as well as the perception and textiles' preferences in different external conditions were studied by researchers in Japan [10] and Hong Kong [11]. The research concerned exposure of a person to cold [10]. The recent studies showed that the subject exposed to cold dressed faster with thicker clothing in the morning than in the evening. Next, they endeavored to answer the question what kind of textile is chosen by volunteers – thin or thick –when they feel cold. It was proven that with exposure to the same temperature, volunteers chose thick garments in the morning and thin in the evening. The researchers pursued their investigation and came to the conclusion that when the temperature of the environment decreased from 33 °C to 25 °C, the volunteers chose a soft piece of cloth instead of a rough one. This was explained as the behavioral thermoregulation of the organism. The touch of a softer piece of cloth evokes the feeling of warmth.

A similar research trend was presented by other authors [11]. They analyzed the relationship among human physiological and psychological thermal and moisture responses in tight-fitting aerobic wear. Results showed that both physiological and psychological responses were significantly influenced by the period of contact with the garments, the garments themselves, the body location and some of their interactions. A multiple regression was used to investigate the connections between the skin microclimate temperature and the humidity (the physiological reaction) and the sensation of changes of the temperature, the humidity and the overall comfort by the users (psychological reaction). The authors tried to estimate which of the above-mentioned parameters influence overall comfort. The results showed that overall comfort depends mostly on the perception of differences in the temperature. The subjective perception of clothing comfort can be predicted on the basis of human physiological and psychological responses in relation to the temperature and the humidity. These authors continued their studies in the field of psychological comfort. The objective of their study was to investigate the predictability of clothing sensory comfort from psychological perceptions by using a feed-forward back-propagation network in an artificial neural network system [12]. In order to achieve the objective, a series of wear trials was conducted in which 10 sensory perceptions (clammy, clingy, damp, sticky, heavy, prickly, scratchy, fit, breathable, and thermal) and overall clothing comfort (*comfort*) were rated by 22 professional athletes in controlled laboratory conditions. They were asked to wear four different garments in each trial and rate the sensations above during a 90-minute exercising period. The scores were input into five different feed-forward back-propagation neural network models, consisting of six different numbers of hidden and output transfer neurons. Results showed a good correlation between predicted and actual comfort ratings, with a significance of $p < 0.001$. These findings develop strongly investigation concerning prediction of the psychological comfort and perception of textile users which may be especially helpful in sport, protection of humans in extreme conditions, like fire protection. However, that approach shows only a single part of the complex matter which is comfort. The essence of textile garments' perception and the possibilities of gaining the information about it were also studied with a different approach [13]. These researches were directed on the analysis of the reaction on two sets of garments: the first – a shirt with short sleeves and trousers with short legs, and the second – a shirt with long sleeves and trousers with long legs. The influence of these sets of garments on the metabolism, thermoregulation, and subjective feelings of users was studied. The expenditure of energy was higher when using the first set of garments in the conditions of 19 °C. Despite this low temperature, male volunteers still felt comfortable, whereas some female volunteers expressed their discomfort and their HB was unstable when using the first set of garments. The analysis of the experimental results showed that not only the subjective feeling of textiles in certain external conditions played an important role, but also, according to researchers, the reaction of the organism on adaptation to external conditions. External conditions determined the perception of textiles by the volunteers, meaning that the fact of real cooling down of the organism was not always consistent with the feeling of cold. The difference between the real energy expenditure, in the case of the first set of garments, in cool external conditions and the sensation of those conditions was observed. Other authors [14] have confirmed that the sensitivity of the human body to the perception of cold varies over sections of the body. The wear trials conducted for their research demonstrated that different locations on the body respond differently to cold stimuli. Another example of this approach is the research [15] that focused on the response of human skin to fabric. These responses included ecyematous dermatitis, percutaneous absorption of chemicals, hydration, water evaporation, changes in bacterial flora of the skin, blood flow, and neural responses.

Other studies have been concerned with elaborating a model showing that the discomfort of the fibers/fabrics can be predicted from a combination of 'tactile' and 'functional' characteristics on the basis of 'appropriateness scaling' [16]. Results revealed that the thermal properties of the textile material and the 'abrasiveness' as authors claim are the most important factors contributing to textile users'(dis)comfort. Other meaningful factors are: fit, tactile and appearance factors, protection and durability. Authors tried to better understand consumer attitudes and stereotypes about fibers, fabrics, and garments in order to help design 'more suitable' uniforms and other types of garments in the future. Such a detailed analysis showed a single aspect of comfort in garments, namely a psychological comfort connected with satisfaction of textile users.

The presented literature review shows only certain possibilities of carrying out the research and possibilities which are seen by scientists in the area of comfort connected with textiles. It was noticed that the fact that an organism reacts to textile garments, e.g. by intensified HB, does not always go with a change of feelings and energy lost in the volunteer. The declaration of the volunteers who use the textiles does not always correspond with a real reaction of the organisms. How can this divergence be explained? The unilateral scientific approach, e.g. only an analysis of the feelings, or perception, without considering the changes in physiological parameters will not guarantee success and will not help to better understand the influence of textiles on humans. Moreover, it may lead to faulty conclusions. It is believed that the method able to link both factors would allow for analyzing the interactions between the perception and physical and physiological phenomena, which occur as a result of the contact between humans and textiles. The methodology proposed by authors may give the answer to the question why certain types of textile seem to be more appropriate for a person (due to comfort, the satisfaction). The information possessed by the quoted scientists reveals only certain attitudes matter to the comfort in textiles. So far, there is no instrument that can reveal the influence of textiles on both human physiological and psychological comfort as well as skin sensorial comfort and ergonomic wear comfort. None of the quoted authors fully studied all types of human comfort in textiles. There is no universal tool, methodology revealing the influence of textiles on humans.

As the majority of human activities aims at improving the existence of human beings, it is necessary to identify the needs of a contemporary textile user and analyze the relations between the textile user and textile products, the experienced feelings while using them, as well as physical and physiological phenomena arising from the closeness of textiles. That is why an innovative approach involving an unconventional method has been proposed to investigate the effects of textiles exerted on their users. This unconventional method, known as corona discharge photography, registers the phenomena created as the effect of recombination of electrons in the air and sweat secreted from the human body whose part is placed within a high voltage and high frequency electrical field in order to observe this recombination. Electrons that come from a live matter may reflect the state of the matter [17, 18]. The occurrence of the phenomenon – a discharge around body parts – has been well known for over two centuries, but it was rendered famous only in the 1950s by Kirlian's photography, owing to the studies carried out in the Soviet Union by Semyon Dawidowicz Kirlian (1900–1980). Then, together with his wife, Valentine, he carried out studies on electrical discharges, and in 1949 he obtained a patent for the device able to register electrical discharge photography also called 'corona discharge photography'. The results of their research and observations were published in a Soviet scientific journal [19], where they described the method developed to register the phenomenon of non-electric transformations of living and non-living objects into electrical transformation.

According to the most up-to-date knowledge, the area of capturing the image of the discharge is now being developed and computerized.

Currently corona discharge photography, also known as bioelectrophotography, is described as a method used to reveal and record corona discharges created around an object, e.g. human fingertips, in two forms – photography and film. An image can be induced when a strong electrical field of high voltage (10 kV) and high frequency (1024 Hz) is produced. A digital camera placed within the area of corona discharges records this phenomenon. A corona discharge is an electrical discharge observed in gases, which occurs on the surface of charged conductors. An electrical impulse transmitted to the plate after placing an object on it, stimulates the response of the object, called *inter alia*, by the movement of charge carriers. Their move-

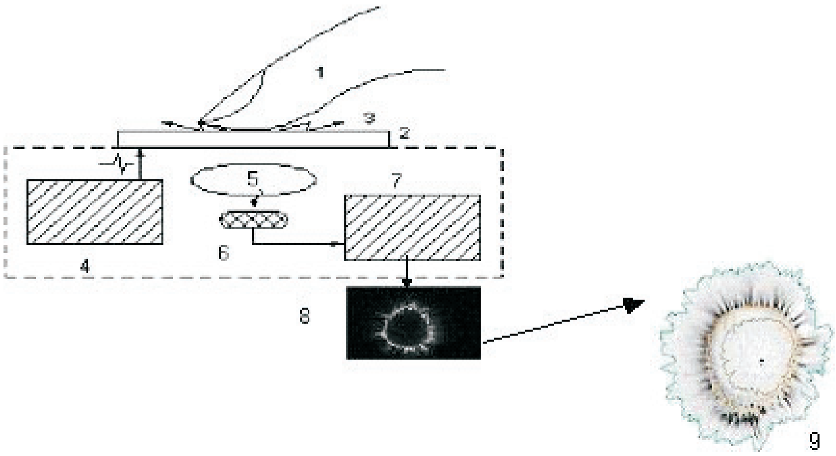

Figure 1 The system used to visualize corona discharge films (CDF) and corona discharge photographs along with the processed photography [6]. 1: study object; 2: optic glass plate connected to a power source; 3: discharge; 4: voltage generator; 5: optic system; 6: CCD camera (charge-coupled device system with charge-coupling technology involving light-sensitive elements); 7: image transducer; 8: image of discharges on the computer monitor; 9: processed and analyzed image of discharges.

ment is constantly accelerated in the conditions of a stable ionization process evoked only by charging a high frequency current [20, 21].

The occurrence of ionization collisions creates an electron avalanche. The ionization (electron dissociation from atom) in the electrical field results from the collision of neutral atoms (or those previously excited) with free electrons accelerated by the field forces [22]. A free electron re-association is followed by a visible glow. This phenomenon is recorded around the fingertip (Figure 1).

An object is placed on the optic plate (1), the voltage generator is on (4), while the generated current parameters are 10 kV and 1024 Hz. In the induced electrical field, charge carriers (free electrons and positive or negative ions) (3) present in the air surrounding the surface of optic plate (2) and the object (1) collide with other charge carriers interacting with one another (they attract themselves and mutually neutralize the excess of different charges) [6].

Numerous recent studies, involving corona discharges, have provided evidence that discharges generated around non-living objects, e.g. coins or stones, do not change their form or shape over time. Corona discharges generated around different liquids [23, 24] as well as around living organisms are characterized by variations over time [17–19].

These observations suggest that registration of a corona discharge around a human fingertip covered naturally by the layer of sweat may reflect the influence of exogenous environmental events, lifestyles, garments and the physical state (also the mental state in humans) of the study objects may influence corona discharges generated around a given animated object.

The amount of sweat substances, e.g. water, sodium chloride, urea, lactic acid, saccharides, potassium, calcium, magnesium, iron, that is excreted by the sweat glands in the skin of the finger determines the character of the discharge created around the fingertip. Therefore, the change of the garments is associated with the change in comfort of the garments' users. This may be connected with changes of the corona discharge around a human fingertip.

This kind of research attempts to determine what factors influence people's feelings towards clothing textiles and, if possible, to estimate them. The phenomenon of corona discharge was employed to find out if it may be a source of information regarding the physiological state of the textile user (that concerns mainly thermophysiological comfort) and psychological state of the textile user (that concerns feelings towards garments and comfort of the person).

Methodology

Three volunteers (one male, aged 28 years, and two females, aged 28–32 years, mean 30 ± 2 years) were eligible for the study. All of them were informed about the purpose of the study and the way the experiment was going to be carried out. They were also trained how to place their finger on the plate in the same manner with the same pressure. All the tests were performed in the following conditions: room temperature of 17–25 °C, relative humidity of 26–40 %, and atmospheric pressure of 980–1012 hPa. On the day of the experiment, they neither smoked nor used medication. The study design was approved by the Bioethics Committee of the Medical University in Lodz, Poland (RNN/336/05/KB).

Examination Methods

They comprised:

- a questionnaire-based rating of the respondents' feeling of comfort, including a 7-item scale with categories of responses ranging from extremely poor to extremely good feeling (the scale was created on the basis of the Positive and Negative Affect Schedule). The following answers were used to describe the frame of mind of the volunteers:

1- I feel very bad (e.g. because I am very anxious and/or because I am strongly depressed);
2- I feel bad (e.g. because I am anxious and/or because I am depressed);
3- I feel rather bad (e.g. because I am slightly anxious and/or because I am slightly depressed);
4- I feel neutral (neither well nor bad);
5- I feel quite well (e.g. because I am slightly excited and/or because I am quite satisfied);
6- I feel well (e.g. because I am in a good mood and/or because I am positively excited);
7- I feel very well (e.g. because I am relaxed and/or I am fully satisfied);

- HB, BP, and measurements of the microclimate (temperature and humidity) between the volunteers' skin and the top cloth;
- measurements of the differences in the potential (static charges) between a volunteer wearing one of the set of clothes and the ground and external conditions monitoring;
- registration of CDF from ring fingertip of the right hand.

The ring finger of the right hand was placed on the plate of the GDV device and a 32-second-long film of corona discharge around the fingertip was recorded. On the first day, a volunteer was wearing a set of clothes made of cotton; on the second day, a set of clothes made of acrylic, polyester and/or polyamide. This procedure was repeated 10 times in total in order to confirm the results. Altogether, the volunteers wore the cotton cloth for 10 days and the synthetic cloth for another 10 days.

CDF were recorded with a GDV camera and film frame parameters were analyzed with the use of the GDV processor program. The ANOVA Friedman test was used to analyze the effect of the kind of clothes on volunteers' level of comfort, HB, BP, microclimate conditions, static charge abilities of clothes on CDF of respondents. Additionally, the influence of external conditions (temperature, humidity, air pressure) on CDF was verified.

The CDF were analyzed taking into account the following parameters:

AREA – the number of pixels of glow image, the number of pixels not removed from the picture during the filtration process and glow area – the number of pixels with non-zero intensity.

AVI – the average value of intensity for all the pixels from glow image, the scale of glow from 0 – black to 255 – white (maximum intensity of glow) was used.

ET – the entropy by the isoline defined as:

$$S(M) = -\sum_{j=1}^{j \leq M} P_j(M)\, ln(P_j(M))$$

where $P_j(M) = N_j/N_M$ denotes the function of allocation of the radius of dots by the isoline of the picture, e.g. probability of value j (N_j – a number of dots with equal value by the isoline) among dots of the isoline length M (N_M – number of all dots on the isoline). The variation between values may be very high; that is why the division into even intervals was used.

FORM C – the form coefficient – the quotient of the isoline length and the average radius multiplied by 2π, reflects a degree of irregularity of the glow contour.

LENG – the length of isoline – the length of the curve of the glow contour corresponding to the average intensity.

AVR – the average radius – the average value of the function $R(a) = R_{max} - R_{min}$ by the angle of inclination of the beam a in [0°; 360°], drawn from the glow center to the nearest dot R_{min} and the most distant from the center R_{max} with the intensity 1 more than the noise level (set on 30, the best for registration of the CDF of fingertips of humans according to Prof. K. Korotkov, DSc).

NRF – the number of free fragments that glow area consists of.

NRMN – the normalized deviation of isoline radius – the quotient deviation of the function $R(a)$ to the average radius **AVR** of the glow.

SD AREA – the standard deviation from the AREA calculated on the basis of the frames registered during film.

SD AVI – the standard deviation from the AVI.

SD FORM C – the standard deviation from the FORM C.

SD LENG – the standard deviation from the LENG.

SD AVR – the standard deviation from the AVR.

SD NRF – the standard deviation from the NRF.

Argumentation

The reasons why the author proposed to carry out the study in the described way, involving the ring finger, were as follows: to date, there have been no reports on the effect of the long-term contact with textiles on corona discharges created around the human fingertips or other parts of the human body; the shapes of fingertip imprints are ellipse-like, and therefore easy to analyze from the mathematical point of view; and there is easy access to fingers (almost always uncovered).

The author decided to register 32-second-long films from corona discharges around the fingertip of the ring finger of the right hand because this finger seems to be the "most sensitive" according to some neurophysiologists [25].

The time of the effect exerted by textiles on a given person (five hours in this experiment) is an important element – hence, the idea of the corona discharge registration around only one finger in order to eliminate confounding factors of the human organism's reaction to textiles. This idea was adopted in the present study. A rationale was found in the neuroanatomy of the right hand ring finger and the fact that the surface of the finger skin is very rich in sweat glands (consideration of wetness of the skin surface). In addition, having performed the test with von Frey hair, it was proved that the ring finger is more sensitive than others [25], and the innervation of the ring finger makes it more sensitive than the other ones.

The decision to use raw materials in the experiment was based on the following prerequisites: a common use of raw materials in clothes, the accumulation of electrostatic charges during material friction, the ability of materials to generate electrostatic charges, and the ability of the hand to feel differences between materials.

Results

Volunteers' Mood

Table 1 The characteristic of the volunteers' mood while wearing different types of clothes.

The description of the volunteers' mood	The number of responses when volunteers were wearing a set of clothes made of cotton	The number of responses when volunteers were wearing a set of clothes made of acrylic, polyamide, polyester
1- I feel very bad because I am very anxious I am strongly depressed	0	0
2- I feel bad because I am anxious I am depressed	7	10
3- I feel rather bad because I am slightly anxious I am slightly depressed	**16**	**21**
4- I feel neutral, neither well nor bad	**13**	**14**
5- I feel quite well as I am slightly excited I am quite satisfied	16	**12**
6- I feel well because I am in a good mood I am positively excited	6	3
7- I feel very well because I am relaxed I am fully satisfied	2	0

The responses given by the volunteers suggested that during use of both sets of clothes, they felt similarly. During the usage of the clothes made of natural raw material (cotton), one could observe more answers that proved the better mood, nos. 5–7, than during usage of clothes made of synthetic raw materials (acrylic, polyamide, polyester). Additionally, volunteers made some comments connected with the clothes they wore. They claimed that clothes made of synthetic raw materials were less comfortable than those made of natural raw material due to thermophysiological comfort and accumulation of static charges.

Physiological Parameters of the Volunteers, Microclimate, Static Charges, and Parameters of the External Conditions

Table 2 The results of measurements.

Parameters	100 % cotton set of clothes			100 % synthetic set of clothes		
	male	female 1	female 2	male	female 1	female 2
HB [beats per minute]	73.33	75.28	70.91	75.68	78.26	71.21
BP systolic [mmHg]	114.41	119.66	114.67	115.50	116.57	114.91
BP diastolic [mmHg]	69.83	75.52	68.16	71.95	76.36	70.04
Microclimate temperature [°C]	33.28	32.64	33.12	34.61	34.24	34.86
Microclimate humidity [%]	31.94	31.04	30.64	30.47	31.67	31.37
Static charges [kV/inch]	+0.04	+0.15	+0.07	–0.45	–0.34	–0.41

Air temperature range: 17–25 °C; relative humidity range: 26–40 %; air pressure range: 980–1012 hPa.

CDF

As a result of the performed experiments, a number of 32-second-long films were produced. During each second, 10 frames of the film were recorded.

The chosen frames (the first out of 320) from the CDF registered around the fingertip of the ring finger of the right hand of the female no. 1 aged 28 years wearing:

100 % cotton clothes

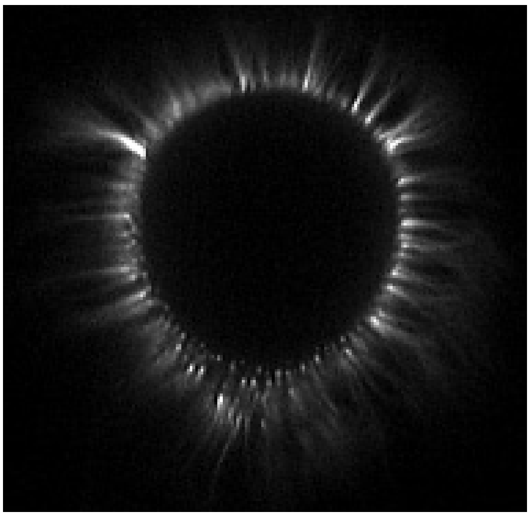

Figure 2 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

100 % acrylic, polyester, polyamide clothes

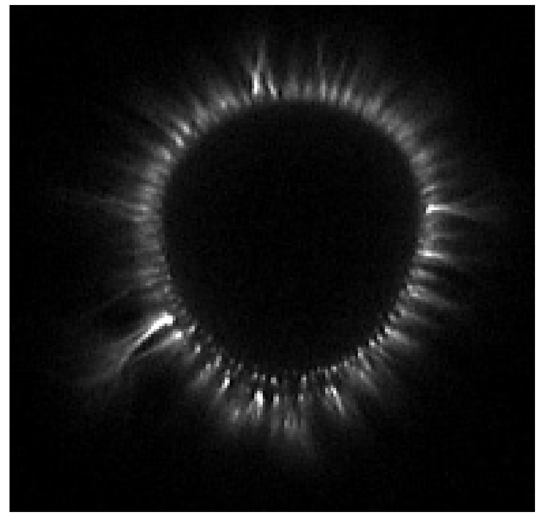

Figure 3 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

The chosen frames from the CDF registered around the fingertip of the ring finger of the right hand of the male aged 28 years wearing:

100 % cotton clothes

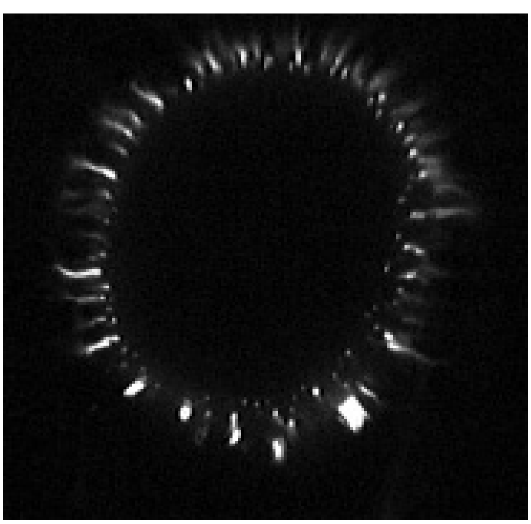

Figure 4 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

100 % acrylic, polyester, polyamide clothes

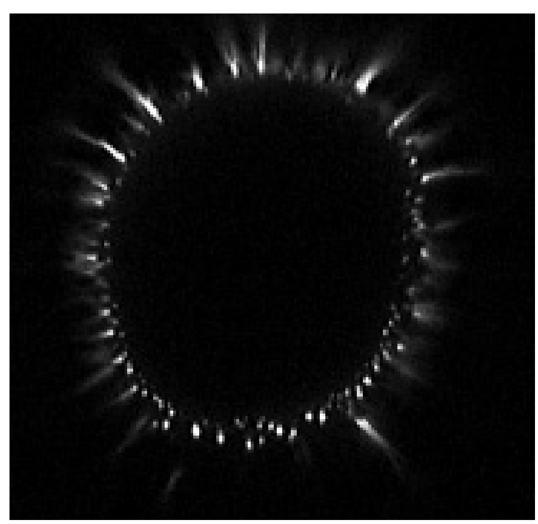

Figure 5 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

The chosen frames from the CDF registered around the fingertip of the ring finger of the right hand of the female no. 2 aged 32 years wearing:

100 % cotton clothes

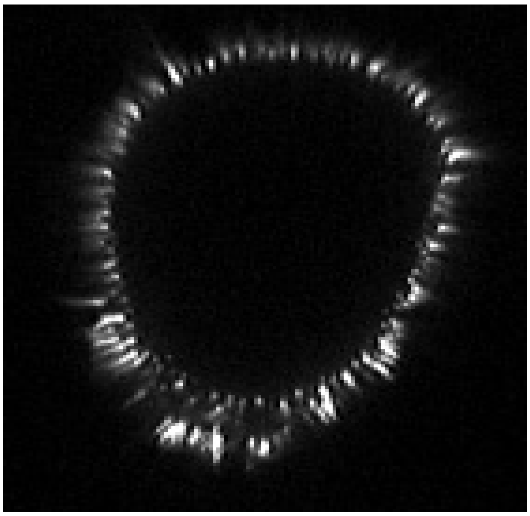

Figure 6 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

100 % acrylic, polyester, polyamide clothes

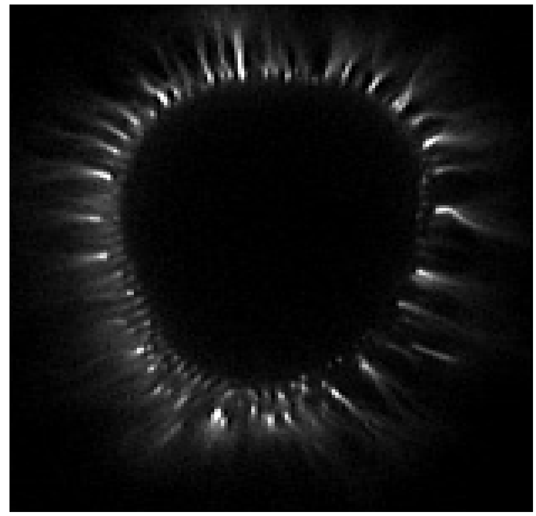

Figure 7 Frame no. 1 from the corona discharge film registered around the fingertip of a volunteer.

Table 3 The levels of significance for the comparison of CDF parameters in dependence on the kind of cloth, 100 % cotton set of clothes and 100 % synthetic set of clothes.

Parameters	100 % cotton set of clothes versus 100 % synthetic set of clothes
AREA	0.0695
AVI	0.0502
ET	0.0958
FORM C	0.0833
LENG	0.0829
AVR	0.0743
NRF	0.0585
NRMN	0.0654
SD AREA	0.0625
SD AVI	0.0885
SD FORM C	0.0781
SD LENG	0.0794
SD AVR	0.0659
SD NRF	0.0765

Statistical Analysis

The statistical analysis was carried out using Statistica software. The Shapiro-Wilk did not confirm the normality of all data distribution. The nonparametric methodology was applied to verify whether the results of tests differ significantly due to type of the clothes. The ANOVA Friedman was employed to compare the appropriate values of CDF parameters, microclimate parameters, static charge parameter, and physiological parameters in both sets of clothes. The statistical significance was $p < 0.05$ for all tests. Additionally, the influence of atmospheric conditions on CDF parameters was analyzed.

The static charge measured on the surface of clothes, which were worn by the volunteers, differed significantly due to the clothes ($p < 0.05$). The static charge was measured by means of a device for contactless detection and measurement of charges on the surface. The measurement was carried out according to EN-PN61340. Although it may seem there is a tendency for making a link between the kind of clothes due to their static charge abilities and the volunteers' mood, no proof for it was found. The difference between the mood of volunteers in dependence to clothes was not significant ($p > 0.05$). There was no significant correlation between the mood of the volunteers and the static charge abilities of the clothes ($p > 0.05$). The same applied to the analysis of the influence of volunteers' mood on CDF parameters. It is believed that CDF parameters may register the changes in sweat amount existing on the human fingertip due to any type of excitation. However, there was no statistically significant influence of the mood of the volunteers on CDF parameters ($p > 0.05$) (although in the case of some CDF parameters, like AVI, $p \geq 0.05$).

There were statistically significant differences in the microclimate temperature measured between the volunteers' skin and the top cloth made of natural raw materials and synthetic raw materials ($p < 0.05$). However, there were no statistically significant differences in the microclimate humidity measured between the volunteers' skin and the top cloth made of natural raw materials and synthetic raw materials ($p > 0.05$).

There was no statistically significant influence of the kind of clothes on mean values of CDF parameters ($p > 0.05$).

The kind of clothes statistically influenced the HB of the volunteers wearing the clothes ($p < 0.05$). There was no influence of the kind of clothes on the BP of the volunteers wearing the clothes ($p > 0.05$).

The analysis confirmed the influence of such factors as the temperature, atmospheric pressure, air humidity on all parameters of CDF recorded during the contact between volunteers of both genders and both sets of clothes ($p < 0.05$). This is congruent with the findings of Korotkov [17], Iovine [18], Loeb [20], Pehek et al. [21], and Opaliński [22].

Discussion

This study confirmed the effect of such factors as temperature, atmospheric pressure, and air humidity on CDF parameters, which has also been reported by other authors [6, 17–22, 26].

The experiments did not reveal differences in CDF parameters dependent on the sets of clothes during a long-term contact in the described conditions and without intensive physical activity. This means that a long-term use of clothes has no impact on CDF parameters that could change them, depending on the set of clothes. This can be associated with the adaptation of the human body to a given textile set. However, one must bear in mind that these parameters were registered after a five-hour use of the set. The author assumes that the textiles themselves give a weak impulse that vanishes over time due to the accommodation process. It is also possible that they provoke a sensor reaction only at the beginning of the contact and that it diminishes after a certain period of time depending on the set of clothes, so that it is not possible to register this reaction by means of CDF. However, it has been proved that a short-term contact with textiles (30 seconds) may exert an effect on the parameters of corona discharge photography [6]. Additionally, the adaptation of receptors to the effect of an external factor depends on a certain condition: if the stimulus evokes a constant stress, receptors stop signaling it (pain is the only exception). The adaptation process is characteristic of skin receptors, which depends on a decrease in the generation potential over time. The ability to detect tactile stimuli is not essential to human survival. It is difficult to estimate the adaptation time to an external impulse, such as textiles. The volunteers' bodies probably got used to the textiles to such an extent that it was not visible on CDF.

Moreover, one noticed that the set of clothes influenced only the microclimate temperature generated between the volunteers' skin and the worn clothes, while the microclimate humidity was not affected.

These findings must be regarded as preliminary on account of the small number of volunteers participating in the experiment.

Conclusions

The interpretation of the results of this study is difficult. This study is one of the first reports on the long-term effect of textiles on CDF variability in humans. The corona discharge photography and film seem to be a source of information only about external conditions like air temperature, air humidity, and air pressure. The factors, such as air temperature, atmospheric pressure, and air humidity influenced all the CDF parameters recorded during the contact of the volunteers (both genders) with both sets of clothes.

The author is moderate in her opinion about the influence of extreme textile-related feelings. The analysis showed that the mood of the volunteers did not influence the CDF parameters.

There were statistically significant differences in the microclimate temperature measured between the skin of the volunteers and top clothes made of natural raw materials and synthetic raw materials, but no statistically significant differences were noted between the mean values of the CDF parameters registered after five hours of wearing the set of clothes made of natural raw materials and synthetic raw materials. The kind of cloth worn by the user may impact his/her HB. The static charge abilities depend on the type of clothes, which is connected with the trybological property of cloth materials.

Acknowledgement

The author would like to express her gratitude to the Polish State Committee for Scientific Research for support (No. 3 T08E 051 27).

Literature Cited

1. Shishoo, R., "Textiles for Sport," Woodhead Publishing Limited, Consulting AB, Sweden, Woodhead Textiles Series No. 45, ISBN 1855739224 (2005).
2. Scott, R. A., "Textile for Protection," Woodhead Publishing Limited, Rascotex, UK, Woodhead Textiles Series No. 44, ISBN 1855739216 (2005).
3. Grabowska, K., Personal Protection by Textiles in the Focus of Stabilization of Thermal Conditions, In: "Proceedings of the 1st Autex Conference," Portugal, pp. 72–75 (2001).
4. Mullen, B., and Johnson, G., "The Psychology of Consumers Behaviour," Lawrance Erlbaum Association, New Jersey (USA), Hove and London (England), ISBN 0898598575 (1990).
5. Nguyen, M. H., and Tokura, H., The Different Effects of Black and White Vietnamese Aodai Folk Costumes on Rectal Temperature and Heart Rate in Woman Walking Intermittently in Hot and Sunny Environment, *Int. J. Occup. Med. Environ. Health* **13**(1), 27–38 (2001).
6. Ciesielska, I. L., and Masajtis, J., The Influence of Textiles on Corona Discharge Created Around the Human Subject Fingertip, *Fibres Textiles East. Eur.* **15**(5–6), 179–184 (2007).
7. Umbach, K. H., Optimization of the Wear Comfort by Suitable Fibre, Yarn and Textile Construction, 40th International Man-made Fibres Congress, Dornbirn, Austria (2001).
8. Umbach, K. H., Measurement and Evaluation of the Physiological Function of Textiles and Garments, 1st Joint Conference Visions of the Textile and Fashion Industry, Seoul, South Korea (2002).
9. Gwosdow, A. R., Stevens, J. C., Berlund, L. G., and Stolwijk, J. A., Skin Friction and Fabric Sensation in Neutral and Warm Environments, *Textile Res. J.* **56**(9), 574–580 (1986).
10. Kim, H. E., Tokura, H., Nagashima, R., and Nishizawa, K., Do Cooled Women Select Soft or Hard Clothing? *J. Therm. Biol.* **20**(4), 327–332 (1995).
11. Wong, A. S. W., and Li, Y., Relationship between Thermophysiological Responses and Psychological Thermal Perception during Exercise Wearing Aerobic Wear, *J. Therm. Biol.* **29**, 791–796 (2004).
12. Wong, A. S. W., Li, Y., Yeung, P. K. W., and Lee, P. W. H., Neural Network Predictions of Human Psychological Perceptions of Clothing Sensory Comfort, *Textile Res. J.* **73**(1), 31–37 (2003).
13. Lee, J. Y., and Choi, J. W., Influences of Clothing Types on Metabolic, Thermal and Subjective Responses in a Cool Environment, *J. Therm. Biol.* **29**, 221–229 (2004).
14. Li, J., Barker, R. L., Wang, Y., and Zhang, W., Cold Sensitivity Differences between Body Sections under Clothing, *Textile Res. J.* **75**, *208–212 (2005).*
15. Hatch, K. L., Markee, N. L., and Maibach, H. I., Skin Response to Fabric – a Review of Studies and Assessment Methods, *Clothing Textiles Res. J.* **10**(4), 54–63 (1992).
16. Schutz, H. G., Cardello, A. V., and Winterhalter, C., Perceptions of Fiber and Fabric Uses and the Factors Contributing to Military Clothing Comfort and Satisfaction, *Textile Res. J.* **75**, 223–232 (2005).
17. Korotkov, K., "Human Energy Field," Backbone Publishing, New York, USA, ISBN 096443119X (2002).
18. Iovine, J., "Kirlian Photography, a Hands-on Guide," Images Publishing, Staten Island, New York, USA, ISBN 0967701708 (1994).
19. Kirlian, S. D., and Kirlian, W. C., Fotografirovanie i wizualnoje nabludenie pri posredstwie took wysokiej czastoty, *Żurnal naucznoj i prokładnoj fotografii i kinematografii* **6**, 397–403 (1961).
20. Loeb, L. B., "Electrical Coronas," University of California Press, London, England (1965).
21. Pehek, J., Kyler, H., and Faust, D., Image Modulation in Corona Discharge Photography, *Science* **194**(4262), 263–270 (1976).
22. Opaliński, J., Kirlian-type Images and the Transport of Thin-film Materials in High-voltage Corona Discharges, *J. Appl. Phys.* **50**(1), 498–504 (1979).
23. Skarja, M., Berden, M., and Jerman, I., Influence of Ionic Composition of Water on Corona Discharge Around Water Drops, *J. Appl. Phys.* **84**(5), 2436–2442 (1998).
24. Korotkov, K., Krizhanovsky, E., Borisova, M., Korotkin, D., Hayes, M., Matravers, P., et al., Time Dynamics of the Gas Discharge Around Drops of Liquids, *J. Appl. Phys.* **95**(7), 3334–3338 (2004).
25. Schweizer, R., Maier, M., Braun, C., and Birbuumer, N., Distribution of Mislocalizations of Tactile Stimuli on the Fingers of the Human Hand, *Somatosens. Mot. Res.* **17**(4), 309–316 (2000).
26. Szosland, J., Wyładowania koronowe w badaniach układu czowiek-odzież, Cz.1, Corona Discharge in Investigation of Man-clothing's System, Part 1, *Przegląd Włókienniczy* **12**, 18–21 (2003) (in Polish).