IMAGES OF CORONA DISCHARGES AS A SOURCE OF INFORMATION ABOUT THE INFLUENCE OF TEXTILES ON HUMANS

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Abstract:

The aim of the experiment was to bring closer the possibilities of using corona discharge photography (CDP), with special emphasis on the impact of textiles on corona discharge photography of human fingertips in contact with those textiles. The article describes an investigation concerning a short period of contact with textiles and their influence on human parameters such as blood pressure (BP) and heart beat (HB) as well as images of corona discharges (ICD). The authors were searching for a new method of demonstrating the influence of textiles on human subjects. As the research involved contact of textiles with human skin, certain static and friction issues were raised. Textile materials were chosen for the experiments on the basis of their tribological features. The ICDs used here were created as a result of placing body parts, e.g. fingers, in the area of a strong electrical field of high voltage (10 KV) and high frequency (1024 Hz). A digital camera placed within the area of discharge recorded this phenomenon. The temperature, air humidity, and air pressure in the examination room as well as gender, age, HR, BP and in the case of female volunteers, their menstrual cycles, exerted an effect on ICD in the study group. ICD of human beings seems to be a kind of marker of tribological features of textile materials.

Key words:

Corona discharge, photography of corona discharge, contact with textiles

1. Introduction

1.1. What is a corona discharge?

A corona discharge is an electrical discharge observed in gases which occurs on the surface of charged conductors. The electrical negative and positive corona discharge has numerous applications in industry, like decomposition of toxic gases, ozone generation, electrostatic precipitation and cleaning [1].

This phenomenon can also be observed around living organisms under certain conditions. This specific usage of corona discharge is the subject of this study.

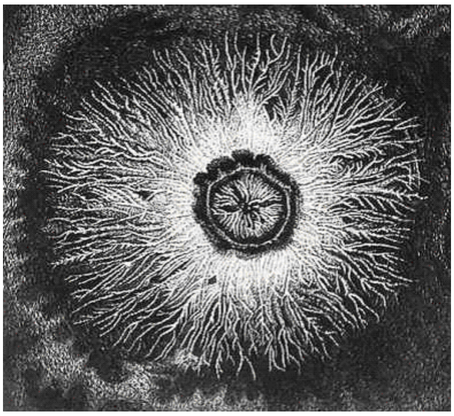


Figure 1. Original Lichtenberg's figure [2].

Many facts about CDP appeared many years ago, thanks to Semyon Dawidowicz Kirlian (1900-1980) but the phenomenon itself was already known to the German scientist Georg Christoph Lichtenberg (1742-1799). He discovered in 1777 that electrical discharges exist around the dust. Although those light shapes around the objects are named Lichtenberg's Figures he could not find any use for them.

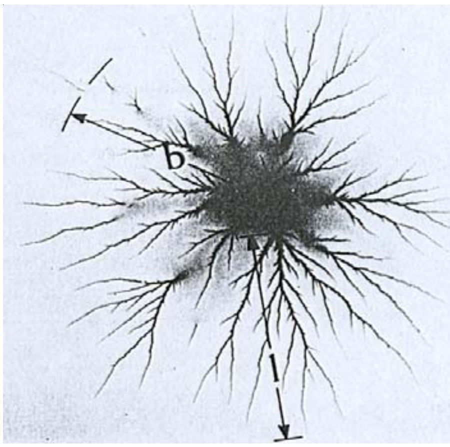


Figure 2. A typical Lichtenberg figure of an emulsion or film. This is a photographic negative with the streamers black against the unexposed film. Note the impact of ten larger streamer branches. These then parallel the surface, branching still more. The central darkening is from diffuse long wavelength ultraviolet from branches. Tips of some smaller branches can be seen on the left. "b" - the radius of the circle containing the impact points of all streamers. "l" – the length of the longest streamer - quotation from page 170 of [3].

One of the Polish explorers, Jacob Jodko-Narkiewicz (1847-1905), a photographer, doctor, and madcap investigator of electromagnetism became famous in that field. In 1896 he published his precursory investigations into 'human aura', as he defined it.

Several dozen years later, those works were creatively continued by the Kirlians from the Soviet Union. The term Kirlian Photography derives from their name [4]. Semyon Dawidowicz Kirlian (1900-1980) was working in the hospital as an electrotechnician and repairing a massage device when he noticed the electrical discharges between a patient's skin and the electrode of that device. He worked out an apparatus to fix this phenomenon. Next, together with his wife, Valentine, he continued research on electrical discharges and in 1949 Kirlian patented a device for registration of electrical discharge photography. The results of their researches and observations were published in 1961 [5]. They described their method as the transformation of non-electric phenomena of living and non-living material. The state of the art analysis of that area of knowledge shows positive development and the advantage of computerisation for capturing the image of the discharge.

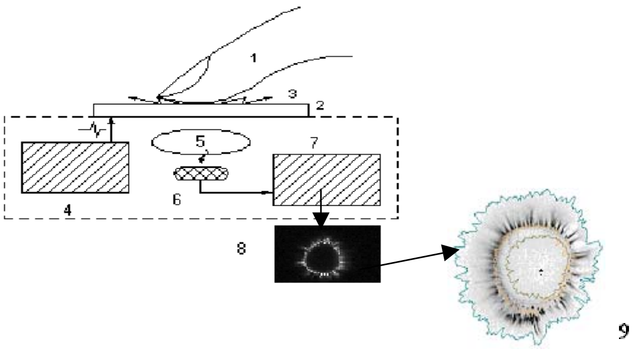


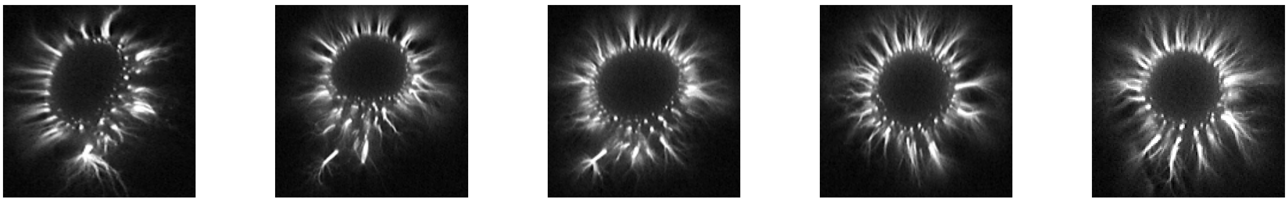
Figure 3. Schematic representation of the system used to visualise ICD along with the processed ICD [18, 19] - 1. study object; 2. optic glass plate connected to a power source; 3. discharge; 4. voltage generator; 5. optic system; 6. CCD camera (Charge-Coupled Device system with charge-coupling, technology involving light-sensitive elements); 7. image transducer; 8. image of discharges on the computer monitor; 9. processed and analysed image of discharges.

1.2. Corona discharge photography

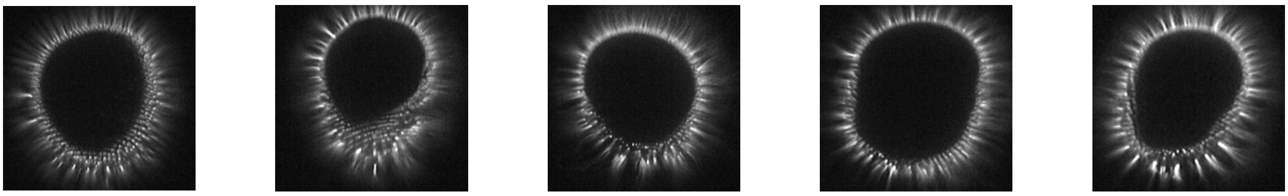
Currently corona discharge photography, also known as a bioelectrophotography, is described as a method used to reveal and record corona discharges created around an object, e.g, human fingertips. An image can be induced when a strong electrical field of high voltage (e.g. 10 Kv) and high frequency (e.g. 1024 Hz) is produced. A digital camera placed within the area of corona discharges records this phenomenon.

In the presented study, a Gas Discharge Visualisation (GDV) Camera was used to visualise images of corona discharges (ICD).

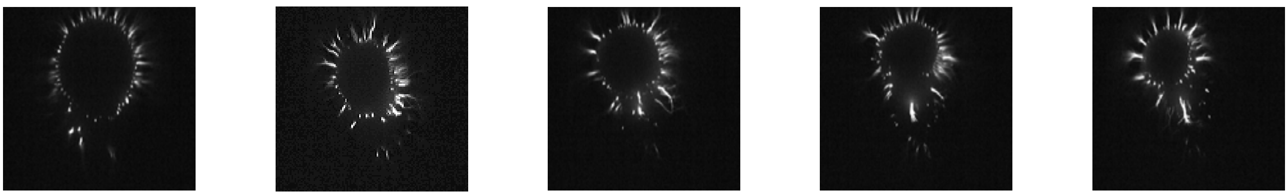
An object is placed on the optic plate (1), the voltage generator is on (4), while the generated current parameters are 10000 kV and 1024 Hz. In the induced electrical field, charge carriers (free electrons and positive or negative ions) (3) present in the air surrounding the surface of optic plate (2) and the object (1) collide with other charge carriers interacting with one another (they attract themselves and mutually neutralise the excess of different charges). An electrical impulse transmitted to the plate after an object is placed on it stimulates the response of the object, by the movement of charge carriers. An acceleration of their movement constantly occurs in the conditions of a stable ionisation process evoked only by charging a high-frequency current [5-9]. The occurrence of ionisation collisions creates an electron avalanche. Ionisation (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 [7- 9]. Free electron re-association is followed by a visible glow. This phenomenon is recorded around the fingertip (Figure 3– 8).



Set no 1. ICD of volunteer: female, aged 28 years, registered from fingertips of right hand (from thumb to little finger).



Set no 2. ICD of volunteer: male, aged 57 years, registered from fingertips of right hand (from thumb to little finger).



Set no 3. ICD of volunteer: male, aged 37 years, registered from fingertips of right hand (from thumb to little finger).

1.3. Living organisms and ICD

Numerous previous 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 living organisms are characterised by variations over time [4, 6, 10, 11,18-20]. This observation suggests that exogenous environmental events, lifestyle, and physical state (also mental state in humans) [12,13] of study objects may influence corona discharges generated around a given animated object [5,14].

In reports published to date, there are certain findings on the effect of changes of raw materials in garments but without reliable ICD image analysis. It is believed that moisture of the element of the body that is placed on the optic plate in the device is one of the most significant factors influencing the variations of the ICD. Change in perspiration strongly depends on the activity of the individual and to the garments s/he wears. Despite the high variability of ICD, one may notice certain patterns that are individual to each person. An exemplary set of ICD shows corona discharge photography registered around fingertips of volunteers: female, aged 28 years - set no 1; male, aged 57 years – set no 2; male, aged 37 years – set no 3.

1.4. Textiles and corona discharge

The position of materials in static tribological order is already well-known. To analyse the influence of textiles on corona discharge photography of human beings in brief contact with those textiles, three different raw materials were chosen: coarse wool – natural, animal fibre (+++), polyacrylonitryl – man-made synthetic polymer fibre (-) and viscose - man-made natural polymer fibre (++).

2. Materials and methods

2.1. Experiment description

In all, 20 volunteers (nine men, aged 21-54 years, mean 46 ± 11 years and eleven women, aged 21-57 years, mean 35 ± 12 years) were eligible for the study. They were students and instructors from the Institute of Architecture of Textiles. All had been informed about the purpose and the experimental procedure and they were all trained in how to place the finger on the plate in the same manner with the same pressure. All tests were performed in the same conditions in room temperature of 18-25 °C, relative humidity of 28-64 % and atmospheric pressure of 986-1010 hPa.

The examination methods comprised: 1. HR, BP measurements and 2. generation of ICD of ring fingertips of the right hand. The other hand was in contact with the textiles. A respondent bared his or her arm from the wrist to the elbow and put on it a knitted textile, a kind of sleeve made of e.g. coarse wool. 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. The procedure was repeated with the use of two other textiles, one made of acrylic and the other of viscose. As a reference, a corona discharge film was recorded when the arm was bare. That procedure was repeated five times in total for each volunteer, in order to confirm the results. During each experiment the respondents wore the same clothes, generally made of cotton, in the whole study group.

ICDs were recorded with a GDV Camera and analysed with the use of the GDV Processor Program and GDV SciLab. Statistica for Windows, version 5.1 was employed in the statistical analysis. A multiple regression was used to analyse the effect of the subjects' examination conditions, their age, gender, HR and BP on the ICD of respondents.

The Bioethics Committee at the Medical University of Lodz gave permission for the research with participation of human beings – agreement no RNN/336/05/KB.

2.2. Theoretical analysis of the scheme of the experiment

The first approach was based on the process of reaction and adaptation of human skin receptors to outside stimuli. Contact of skin with textiles evokes a certain reaction of receptors. It was considered that the possible reaction to textiles may be an example of ICDs' parameter changes. It was believed that textiles evoke reactions of organisms that can be visible on ICD.

The second approach undertook the analysis of the generation of charges during static and friction contact of human beings with textiles. Tribo-electrification is the phenomenon whereby electrical charge is generated from abrasion between the relative motions of two contacting surfaces. It is highly dependent on the nature of the materials, the adhesion conditions and the degree of friction and wear [15, 17].

In this study it concerns the human forearm and a textile sleeve. It is known that the human body undergoes electrification mainly because of:

- walking (contact of bottom of footwear with a floor surface and distancing of feet from floor);
- friction of body by clothes;
- contact with electrified materials, e.g. textiles;
- staying in an electric field (induction).

Let us consider the steps of the experiment:

Step 1: The volunteer came into the laboratory wearing a set of garments (cotton). The person has already got certain potential.

Step 2: The volunteer wears on his bare arm a textile sleeve (100% acrylic). The potential of the person has changed. Friction process takes place between skin and textile material and additionally contact with textile material itself may influence the potential of the whole object with sleeve (person+ sleeve).

Figure 4. The wearing of the sleeve on the left arm [own researches of author].

Step 3: A volunteer keeps a sleeve on his left arm and at the same time the ring finger of his right hand is in the electric field. An ICD is registered around this finger.

Figure 5. The Gas Discharge Visualisation Camera designed by Konstantin Korotkov, Professor of Physics at St. Petersburg State Technical University in Russia [own researches of author].

Why the ring finger of the right hand?

- Because of easy access to this part of the body. No necessity to remove garments.
- Any part would be sufficient but an ICD of this part of the body is easy to analyse, and it might be compared to a circle or an ellipse. One should also remember the different perspiration activities of different areas of the body. Fingers seem to be (given the wetness of the skin surface) the richest areas as far as the sweat glands are concerned.

Some neurophysiologists believe that the ring finger is more sensitive than others, and it was in fact proved by a von Frey Hair test [16].

Step 4: The volunteer takes off the textile acrylic sleeve and wears the textile viscose sleeve. The friction process takes place between the skin and the textile material and additional contact with the textile material itself may impact on the whole object with the sleeve (person+ sleeve).

Step 5: On the left arm a volunteer wears a sleeve and at the same time the ring finger of the right hand of the volunteer is in the electric field. An ICD is registered around this finger.

Step 6: The volunteer takes off the textile viscose sleeve and wears the textile coarse wool sleeve. The friction process takes place between the skin and the textile material and additional contact with the textile material itself may impact on the whole object with the sleeve (person+ sleeve).

Step 7: On the left arm a volunteer wears a sleeve and at the same time the ring finger of the right hand of the volunteer is in the electric field. An ICD is registered around this finger.

Step 8: The volunteer takes off the textile coarse wool sleeve and leaves his arm bare. The friction process between the skin and the textile material takes place while the sleeve is taken off. 3.

3. Results

As a result of the performed experiments a number of 32-sec-films were produced. During each second ten frames of the film were recorded. The chosen frames extracted from the 32-sec-long films of corona discharge created around the fingertip of the ring finger of right hand of female, aged 43 years are shown in Figures 6-29.

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of acrylic knitted fabric

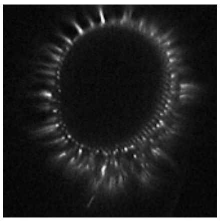


Figure 6. Frame no 1. (The total area of discharge in pixels (TAD) = 6580)

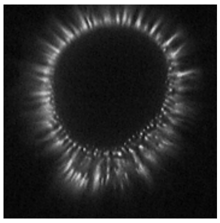


Figure 7. Frame no 160. (TAD = 7521)

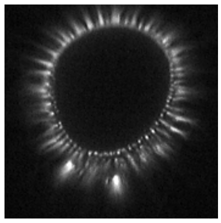


Figure 8. Frame no 320. (TAD = 7694)

Frames from the 32-second-long film registered when a volunteer does not wear a sleeve on her left forearm.

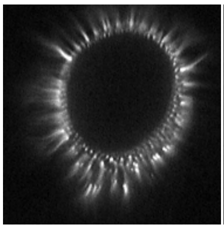


Figure 9. Frame no 1. (TAD = 9553)

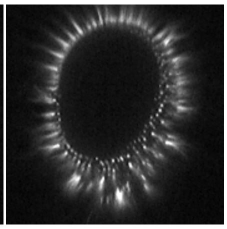


Figure 10. Frame no 160. (TAD = 10821)

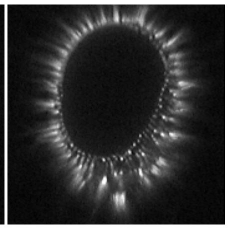


Figure 11. Frame no 320. (TAD = 10979)

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of knitted viscose fabric

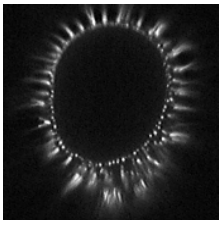


Figure 12. Frame no 1. (TAD = 9186)

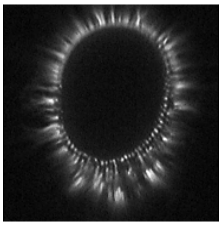


Figure 13. Frame no 160. (TAD = 10854)

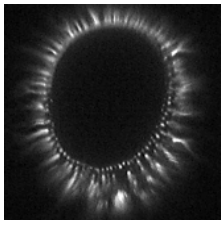


Figure 14. Frame no 320. (TAD = 11026)

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of knitted wool fabric.

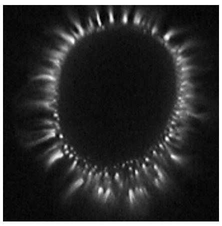


Figure 15. Frame no 1. (TAD = 7955)

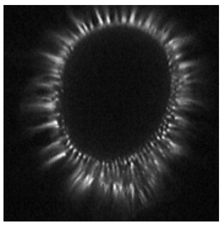


Figure 16. Frame no 160. (TAD = 9334)

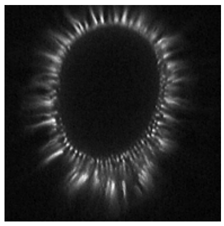


Figure 17. Frame no 320. (TAD = 8987)

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of knitted acrylic fabric

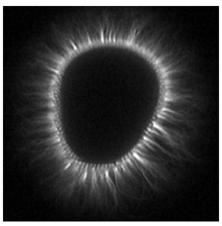


Figure 18. Frame no 1. (TAD = 14283)

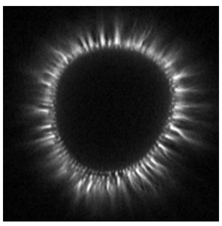


Figure 19. Frame no 160. (TAD = 9273)

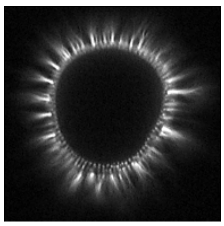


Figure 20. Frame no 320. (TAD = 9988)

Frames from the 32-second-long film registered when a volunteer does not wear a sleeve on her left forearm.

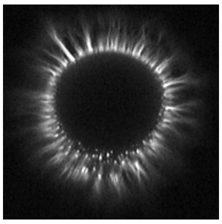


Figure 21. Frame no 1. (TAD = 12991)

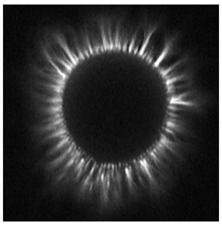


Figure 22. Frame no 160. (TAD = 12985)

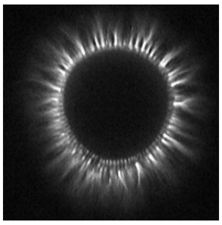


Figure 23. Frame no 320. (TAD = 13103)

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of knitted viscose fabric.

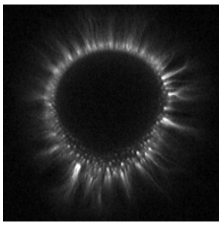


Figure 24. Frame no 1. (TAD = 13694)

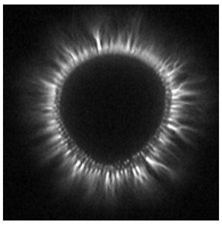


Figure 25. Frame no 160. (TAD = 12135)

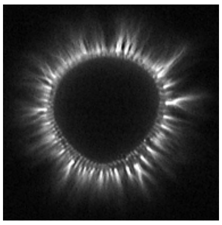


Figure 26. Frame no 320. (TAD = 12156)

Frames from the 32-second-long film registered when a volunteer wears on her left forearm a sleeve made of knitted wool fabric.

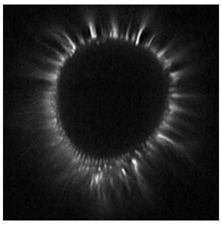


Figure 27. Frame no 1. (TAD = 11985)

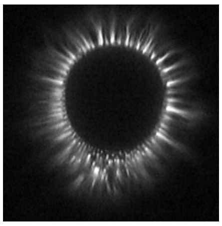


Figure 28. Frame no 160. (TAD = 12021)

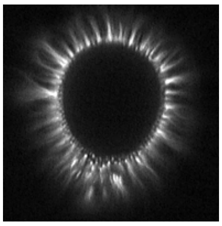


Figure 29. Frame no 320. (TAD = 12133)

The GDV SciLab program calculates the following parameters of film:

- The total area of discharge in pixels (TAD).
- Coefficient of shape (a quotient of the length of isoline to the mean length of radius multiplied by 2).
- Mean length of radius (length section being the result of subtraction between the maximum distant and the minimum distant pixel from the centre of ICD with both pixels lying on the same radius of ICD).
- Normalised deviation of isoline radius (the quotient of standard deviation of isoline to the mean value of the length of radius of ICD.
- Mean brightness (in the range 0-255).
- The number of fragments of the image (the number of separate fragments of the picture).
- The analysis of the 32-second-long films from corona discharges shows that:
- There is a linear correlation r = 0.8 between parameters of ICD, defined for all films recorded during contact with knitted fabrics and without knitted fabric.
- There are significant statistical differences between mean values of parameters of ICD recorded during contact with knitted acrylic fabric and knitted viscose fabric (p=0.0240), knitted acrylic fabric and knitted wool fabric (p=0,0210), knitted acrylic fabric and lack of any fabric (bare arm) (p=0.0080) as well as during contact with knitted wool and viscose fabrics (p=0.4980), viscose and lack of any fabric (p=0.0450) and wool and lack of any fabric (p=0.0340).
- There is no correlation between parameters of ICD in the frame of repetitions of contact with fabrics and without fabric. There are no significant statistical differences between mean values of parameters of ICD in the frame of repetition of contact with each textile or without (p=0.5693).
- There are significant statistical differences between the mean length of radius (p=0.01050) and the coefficient of shape (p=0.0144) in ICD recorded for women and men. Moreover, as regards the mean length of radius, mean brightness, number of fragments of the ICDs recorded during contact of volunteers with knitted fabrics.
- Menstrual cycle of female volunteers; the later the day of the cycle, the higher the value of standard deviation from the mean length of radius and the lower the value of standard deviation of numbers of fragments.
- Gender of volunteers; in ICDs recorded from fingertips of men, the length of isoline is higher than from fingertips of women – it derives from the anatomical differences as usually bigger fingertips are observed in males than females.
- Air humidity; the higher the humidity, the higher the length of isoline.
- Age of respondents and their BP; the older the person, the higher the value of form coefficient.

4. Discussion

This is one of the first reports on the influence of textiles on variability in ICD generation of human beings. This research has confirmed the influence of factors like temperature and atmospheric pressure, air humidity, HR, BP, age, gender and menstrual cycle on ICD, which had already been reported by authors of other publications [4-8].

Significant statistical differences between all parameters of ICD in the case of contact with knitted acrylic fabric and other fabrics as well as while there was no contact with fabrics are puzzling.

It may be connected with skin sensory factors and the process of adaptation of organisms to a new object – textiles. Not only the subjective sensory perception (touch) could play a role here, however, but also greater ability of the fabric to charge accumulation. It is noteworthy that the raw material of garments worn by the respondents during the experiment might also have influenced their ICDs. It means that the influence of garments on ICDs of humans should be given consideration. It may be connected with an electrostatic charge, which is accumulated on the surface of clothes and additionally decides the human electrostatic potential (human + clothes). Hence, it could determine 'the response' in ICD's changeable character. Detailed analysis is only possible with parametric analysis of the digital ICDs. ICDs of respondents allow general gradation of the textiles with which they have contact. It means that a range of textiles made of different raw materials such as coarse wool, acrylic and viscose are factors influencing the changeability of parameters of 32-second-long film of corona discharge registered around the fingertips of volunteers after short periods of contact with those textiles. The reason for the differences might be the duration of the process of adaptation by the organism (the adaptation of the organism to the textiles while registering the discharges) and adaptation of receptors in human skin to the textiles. Although there is a possibility of ranging the textiles: the lowest value of TAD was gained when a volunteer had contact with acrylic fabric, a higher value of this parameter was obtained by wool, then viscose, and the highest value was achieved when a volunteer did not have contact with any fabric in the form of a sleeve. The presented results are true only for 65% of the examined population. In 30% of the remainder certain deviations from the presented order were noticed. They concern the differences between the range of viscose and lack of sleeve. In 5% of the examined population deviations from the order presented above were noted. They seem to be a consequence of the individual features of examined subjects, e.g. perspiration, skin roughness.

5. Conclusion

1. There is no ground for considering registered films as sufficient evidence of whether the impact of outside factors, i.e. textiles, has an advantageous or disadvantageous effect on human beings. Potential created while they are wearing sleeves might be reflected in ICD because of the generation of charges between the skin of the forearm and the surface of the fabric. The reflection is possible on account of the fact that a human finger plays the role of an electrode in a GDV Camera device. Discharge photography may mean there is a possibility of analysing the peak voltage of the object (human+textiles).
2. It is likely that further studies of electrography will contribute to better use of the observed changes in corona discharges in assessing influences of outside factors on human beings, like detecting uncomfortable textiles.

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