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THE PHENOMENON OF STABILITY OF THE AVERAGE VALUE OF ELECTROCUTANEOUS CONDUCTIVITY IN "POINTS- SOURCES OF THE MERIDIANS"

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Abstract
The present work is the attempt to improve the quality of electro- acupuncture diagnostics. For this purpose, a study involving 210 volunteers, over three years, in different seasons was provided. Definition the statistically homogeneous data as an array comprising the measuring of electrocutaneous characteristics in every separate "point - source" and the visualization the results obtained in this way, make possible to observe the stability of the average values of the "point - source" data. It also makes possible to assume the permissible range of normal and abnormal values of electrodermal characteristics.

Keywords: point - source, electrodermal characteristics, statistic processing, visualization

Introduction

The research methods of the electrical properties of different parts of the human skin allow to measure conductivity or electrodermal resistance (reciprocal). Also these research methods use correlation between the electrodermal characteristics (EDC) of the certain skin micro zones and the condition of the internal organs and systems of a human being. Starting with the researches of R. Voll and I. Nakatani in 40^{th} – 50^{th} of the XX century, authors have been noting that on the micro zones (MZ) which correspond to the points described in the traditional Chinese medicine as acupuncture points throughout the human body, the resistance of the skin drops sharply to 70÷300 ohm. The area of these parts of skin is 1-:-2 mm^2. [1],[2],[3]..

The purpose of the work is:

1. to analyze common measurement methods for electrodermal conductivity in micro-zones;
2. to analyze the ways of processing the results of measurements of the EDC of MZs by different methods;
3. to describe the measurement method and the approach of statistical processing of the measurement results of EDC given by the authors.

Methods and equipment.

For measuring EDC of MZs "Rada-5" device was chosen. It is similar to Nakatani device, with some modernization: modern electronic components; the circuitry of this device is characterized by the high noise immunity and low temperature drift of zero that provides electrodermal measurement accuracy. The main measuring appliance of the device is automatically balanced Wheatstone bridge which is extremely sensitive to the smallest changes in the conductivity of the measured object. The dry point electrode carried out the measurement.

The power is derived from an 18V battery, with the DC of 1÷20 μA, negative polarity. Controlled parameter was the DC conductance in microzones.

The Certificate on the state supervision, which is annually held by the Department of Standardization and Metrology, confirms the reliability and validity of the measuring device.

The members of the surveyed group were homogeneous by age and occupation (medical university students, men and women, with average age of 18,41 ± 0,35 years). The total number of participants was 210 persons, 93 men and 117 women.

Some persons took part in all the seasons of measurements; some persons were examined only once. Inside every measurement season, one person could be observed several times.

All these persons are only volunteers. They were randomly selected from the students' community. All participants signed an agreement stating that without any coercion they agree to participate in the study; they know the purpose of the investigation; they are familiar with the applicable research methods and do not have any objections. The design of the study, matching the chosen methods with International Bioethics Conventions was confirmed by the decision of the University Bioethics Commission. According to it, design and conditions of the study meet the ethical, moral and legal requirements and international and domestic legal documents: the Geneva doctors Declaration (General Assembly VMA, 1948, amended in 1968, 1983 and 1994); Helsinki Declaration (WMA

General Assembly, in 1964 with additions in 1975, 1983, 1989, 1996, 2000); Standards ICHGCR, 1996.

Primarily all participants went through a baseline medical examination: clinical blood and urine tests, ECG monitoring, examination by a pulmonologist, gastroenterologist, surgeon, dentist; women were also examined by a gynecologist. All participants got the medical commission conclusion - "NAD" (nothing abnormal detected).

The reason for the participant rejection could be the presence of chronic or congenital diseases, or for the first time identified the functional state of abnormalities or excess or very low weight. Also, it could be participant's own decision to refuse any time.

For our study, we have chosen the same controlling MZs as in the Nakatani method: 24 MZs (points- "sources") – 12 on the right and 12 on the left side of the body. These points are placed on the ankles and wrists. The measurements have been performing throughout the year. Each measurement was taken at the same time – 12:00 – 12:30.

Statistical analysis of the results was performed by means of STATISTICA 6.0 software. After studying the obtained data, it was found that the results of measurements in each micro-zone have a normal distribution. Therefore, the adequate descriptive statistics of the data are the average value and confidence interval.

Results

The known methods for measuring EDC MZs of Voll and Nakatani [2],[3],[4],[5] are based on the application of the wettable electrode. As regards this electrolytic solution, such electrode brings an error in the measurement results due to its own high conductivity. The formula of common MZ conductance with the wettable electrode:

$$Gcom = GMZ + GES, \quad (1)$$

where Gcom – common measured conductance;

GMZ – MZ conductance;

GES - electrolytic solution conductance.

It is understood that the higher conductivity of the electrolyte, the less the MZ contribution to the overall measured conductivity.

These methods make their attempts to find and show the criterion of patient's good functional state. As in other diagnostics methods, the parameters of good functional state determined in Voll and Nakatani methods are probably variative, they may change from some minimal to some maximal value. These methods are similar in a manner of formulation the conclusions about the subject's functional state, which is based on the formation of "physiological norm corridor." This average value is calculated from all the points-sources of the particular person in the time of a single measurement of EDC MZs.

If the patient's EDC is not less than minimal and not more than maximal value, i.e. is inside of this "norm corridor", patient is healthy.

Both the methods are based on the assumption that all MZs of healthy person have the same conductivity and a similar "norm corridor". Nakatani method [5],[6] accepts a prior assumption that the current functional state of an organism is determined by the same EDC value for all MZs, and in a healthy organism, all MZs should have the same conductivity.

In studies held by Nakatani it was found that the MZs of some meridians always display more (or less) higher conductivity values than the MZ of other meridians. The width of the "corridor norm" in this method exceeds the statistical error of measurement; its calculation is not explained.

In the Voll method [3],[4] "norm corridor" is just in the range of 50 to 65 scale units (or percents). Indications EDC MZs below 50 and above 65 units of the scale attributed to presence of various pathologies.

However, these methods have no references to the reason why this breadth "normal corridor" may be considered as acceptable.

These methods approve that statistically homogenous are the measurements of all the MZs of one subject, measured one-by-one.

We believe that these parameters are the group of single measurements in every separate MZ. So these parameters are not statistically homogeneous because every such measurement is new EDC measurement of another MZ. Every MZ reflects the state of another functional system, meridian or organ.

After analyzing the existing methods of EDC measurements in MZs and the means of a diagnostic conclusion formation, we performed our own research of EDC in MZs for that afore mentioned group.

It is the significant difference with Nakatani method – the electrolyte conductivity is not involved into the measurement circuit.

The measurement results were recorded into the summary tables, where every line consists of all the results of measurements from one examined person and every column contains the results from one MZ of the entire surveyed group of students.

Discussion

We believe that just because of non-correct statistical processing of the measurement results EDC methods cannot take their place in the field of reliable diagnostic methods.

The result of processing has excluded the deductive assumption that all MZs of the body should have the same value of "norm" and therefore there may have the same "norm corridor" for all MZs.

All reviewed ways of determination the EDC in MZs are based on the single theoretical method – traditional acupuncture. The researchers determine EDC not of the skin on different parts of the body. EDC should be determined of the particular organs and systems in each MZ. The functional state and changes of these organs and systems are reflected by the measured parameters of the MZs due to the skin-visceral relations. Calculating the average value for all measured MZs violates a fundamental principle of uniformity of the analyzed data in the statistics, as in the methods of Voll and Nakatani. Although the average value can be calculated, it does not describe any basic properties of the provided set of MZs.

In order to get the comparable results the measured values should be normalized. To do this, each measurement should start from the calibration of the device scale i.e. from adaptation of the measuring scale to the skin properties of each individual. In this case, the calibration is carried out by putting the arrow to the position of "100" on the measuring scale of the device, when the electrodes are short-circuited through the human body. Short circuit runs at a maximum touch of the measuring and the indifferent electrodes to the human skin. Thereby, all the data obtained are normalized that allows comparing them and then finding adequate statistical characteristics. It can be calculated as a percentage of the maximal indication of scale for each person. The measurement time of each test point is 2-5 seconds until getting the maximum of measurement. The intensity of pressing on the measuring electrode should not cause unpleasant feeling of the excessive pressure for the surveyed.

The results of the measurements of electrodermal characteristics of MZs are recorded in the table.

Table 1.

The example of the observation table.

N pat.	P (H1)	MC (H2)	C (H3)	IG (H4)	TR (H5)	GI (H6)	RP (F1)	F (F2)	R (F3)	V (F4)	VB (F5)	E (F6)
1	51	42	41	15	5	4	35	41	33	40	10	23
2	10	29	34	9	6	5	58	92	27	35	10	7
3	65	45	26	51	3	6	57	77	48	48	30	25
4	36	31	30	28	18	10	44	43	37	72	29	43
5	44	37	33	42	26	29	37	45	40	23	31	42
6…	27	17	17	7	9	5	32	72	33	32	12	28
65	38	65	51	48	35	36	37	35	43	40	33	42
∑	**32,09**	**33,75**	**24,67**	**23,2**	**9,98**	**11,86**	**59,53**	**61,72**	**33,06**	**55,78**	**18,45**	**27,21**

Each line of such table corresponds to one measurement of all parameters of the EDC MZs from one person. The number N is the number of observations.

Each cell of the line «Σ» contains average values EDC for every MZ.

$$=\frac{\sum_1^N Ai_N}{N};\ A\in[H,F];\ i=1\div6. \qquad (2)$$

"H" and "F" are mean points on the hands and feet.

Each column of the formed table with initial data contains information of the EDC MZs, i.e. there are homogeneous data in each column, and it is possible to calculate descriptive statistics for them. These descriptive statistics in this case are informative – average value, standard deviation, confidence intervals. Using this approach the average value which was calculated for each column does not show the average conductivity of the skin, but the average values of the EDC of the specific organ or system for the surveyed group or one particular surveyed in a given period of time. The essence of the proposed method of processing the measurements' results is that first of all there should be formed an array of data across the surveyed group and then the average value can be calculated for each MZ. In this way, they can be compared as relative changes in the parameters of a particular organ or system [7].

Thus, the average value of EDC MZs can be visualized. The graph of the averages is suitable for visual analysis of the results of EDC measurements of MZs for any person from an array of measurement by comparison as in Fig. 1

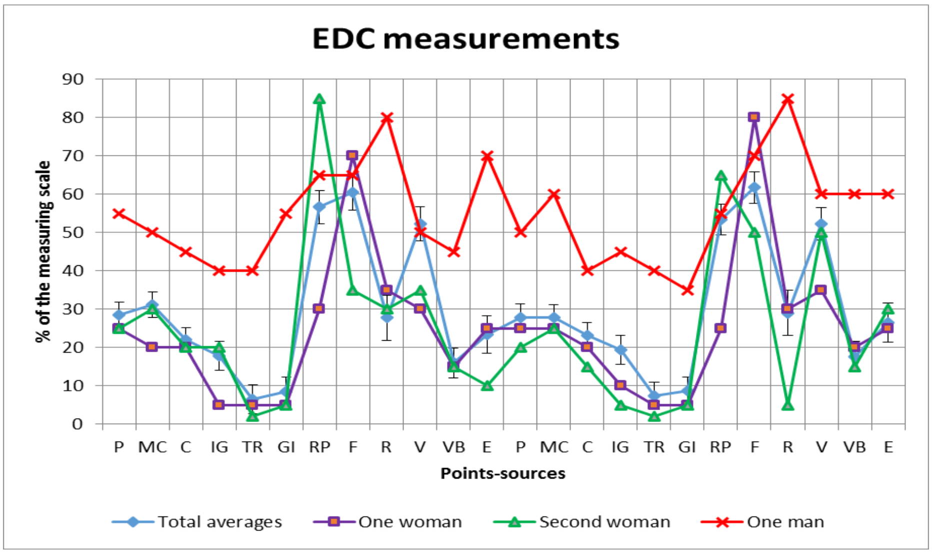

Figure 1. Graph of the EDC MZs averages. Graph "Total averages" is shown with error bars.

The following names of the Meridians are represented by the popular French nomenclature: P – lung; MC- pericardium; C – heart; IG – small intestine; TR – triple warmer; GI – great intestine; RP – pancreas; F- liver; R – kidney; V- bladder; VB – gallbladder; E- stomach.

It is clearly seen that the right side of the graph with group mean values, which represents the values of EDC MZs on the right side of the body is similar to the left side.

According to the defined rules, there was held a number of measurements. They covered all seasons, various temperature and atmospheric conditions. The research also allowed to identify gender differences in measurements of EDC MZs.

All graphs are similar; however, they have their distinctive features. We can see that in every season the women's mean values are consistently below the average values of men. The diagrams of men and women have their peaks at different points but they are similar to each other on the right and on the left.

Winter measurements, which were held in December, showed: high amplitude of the variational series; peculiar allocation of the values of the EDC of MZs; similarity of the indicators for both women and men.

The conditions under which the series of winter measurements were carried out were the following: the outside air temperature was from -7 ºC to -10 ºC, atmospheric pressure – 750 mmHg; temperature of the room where the research was held was +21 ºC. (Fig.2).

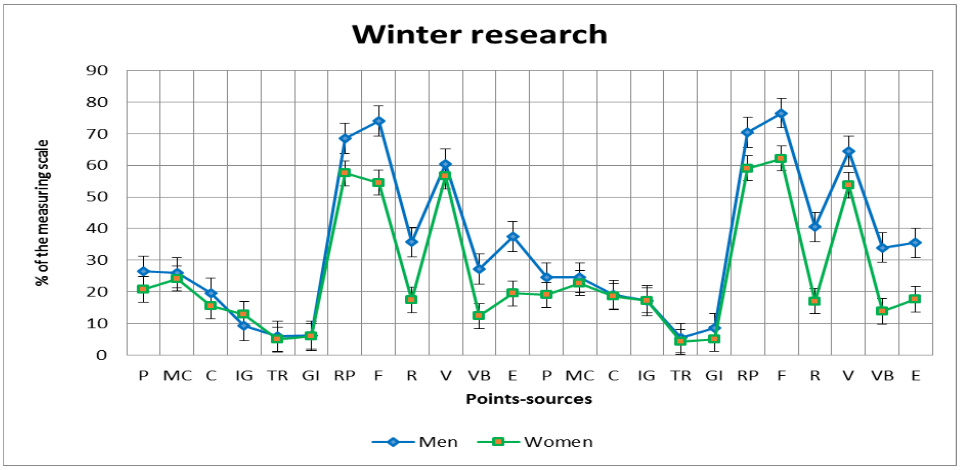

Figure 2. Graphs of the mean values of the EDC MZs during winter measurement series Men – 57, Women – 51.

The amplitude of the variational series for men is 76, for women it is 54. The similarity of graphs showing the mutual relative allocation of the EDC parameters is very well expressed.

The graphs of the autumn measurements are quite similar by their appearance to the winter ones. The room and outside air temperature during the autumn measurements was +23 ºC; atmospheric pressure was 755 mmHg, with a windless fair weather. The winter and autumn graphics for women are especially similar. Gender differences are well expressed in the diagrams of the autumn series. (Fig. 3).

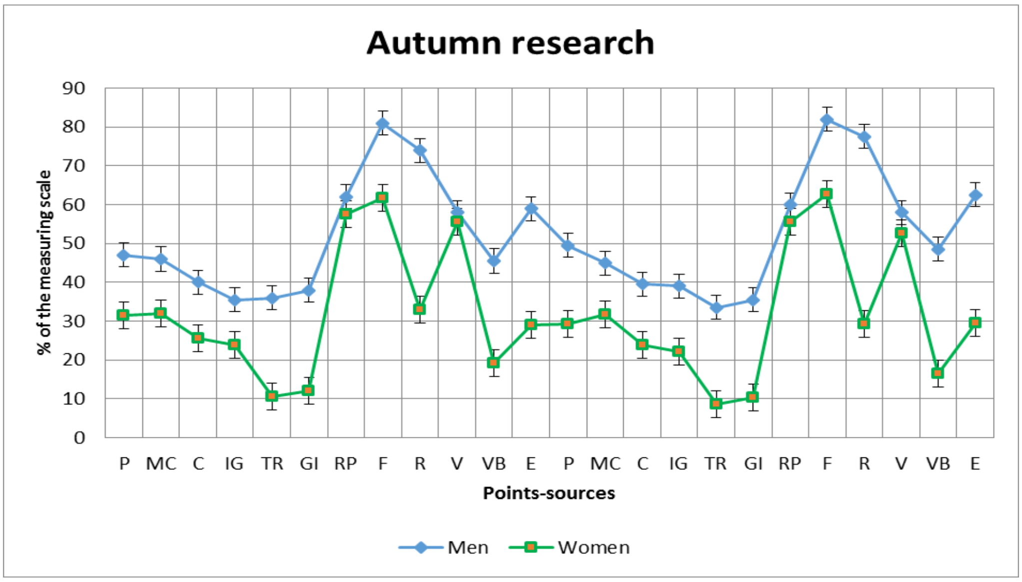

Figure 3. Graphs of autumn researches. Men – 73, Women – 80.

While summer measurements the temperature outside and in the room was from +31 ºC to +33 ºC. Also this temperature was constant during two weeks before the measurements. The limits of the women's graph were less expressed in summer series than in winter and autumn measurements. And the shape of the men's graph is noticeably different from the women's one as there is an area of the increased conductivity. It is identical on the left as well as on the right side. Figure 4 demonstrates group charts showing the imposition of the measurements from the right and left sides of the body. It is evident that the summer curve of men, which was obtained during the temperature stress, differs from the winter and autumn curves. (Fig.4).

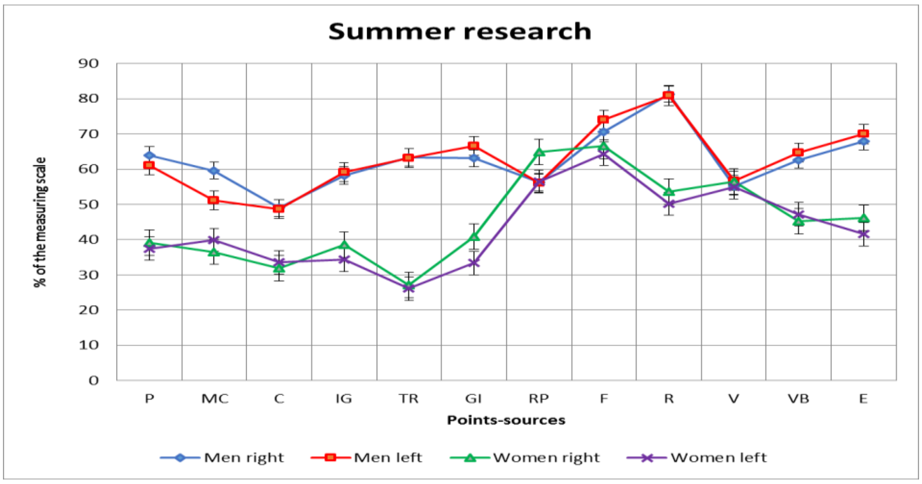

Figure 4. Graphs of summer researches. Men – 61, Women – 76.

Nevertheless, as for women the graphs of the right and left sides of the body almost coincide with each other.

Gender differences are also well expressed in the diagrams of all the series. Though the reaction of men's and women's EDC MZs is different, it has good reflection. For example, we made the EDC registration in the class group (men and women) before and after their usual studies in the computer classroom. Figure 5 illustrates group charts showing the imposition of the measurements from the right and left sides of the body. (Fig.5).

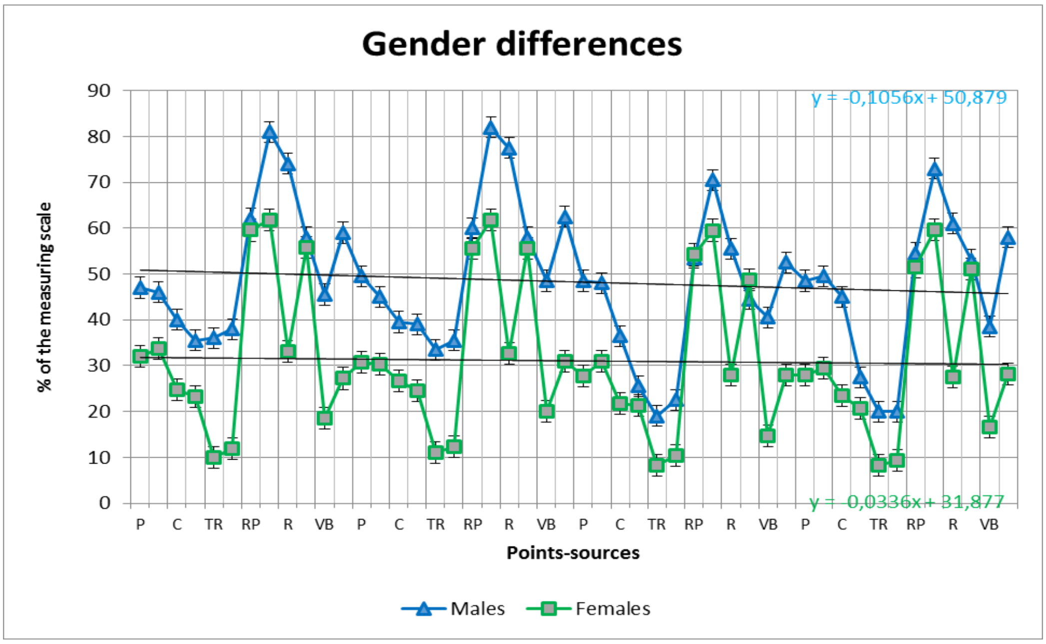

Figure 5. The graph of the mean values of the EDC, taken in the computer class. Autumn measurement season. Males – 73, females – 80.

The showing graph consists of four well-differing parts: right, left measurements before class; right, left measurements after class. The total average of women's EDC is approximately 60% of the same indicator for men.

Unlike men, women show greater stability of the functional systems to the influence of stress which they have during their class studies. Similar changes were registered using methods of heart rate variability and upper limbs' rheovasography.

Figure 6 represents four seasons. This graph clearly shows that regardless to the season, those parts of the graph, which show the mean value of the EDC MZs on the right side of the body, are always similar to the corresponding parts on the left side. Also all generalized charts are similar to each other.

Winter chart has the widest amplitude and summer chart has the shortest. However, the shape of the curve is always maintained. (Fig.6)

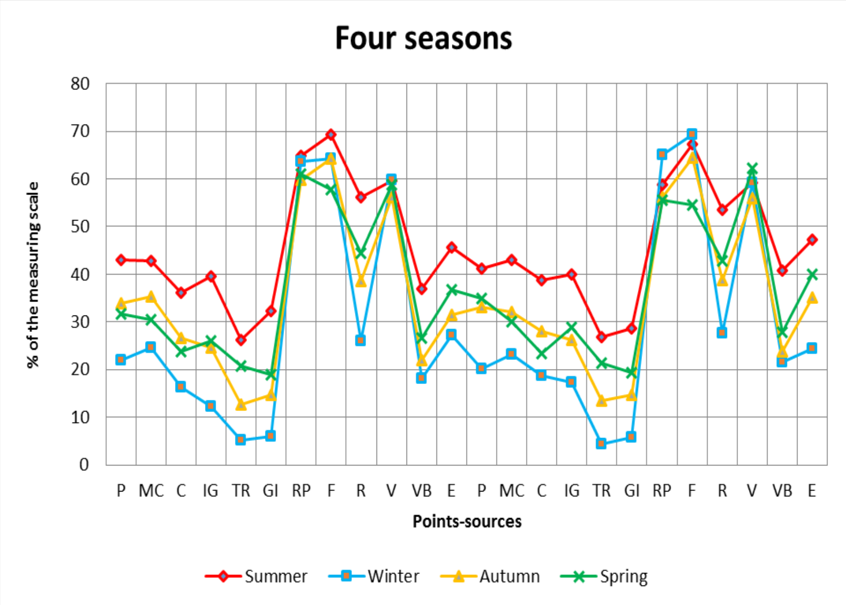

Figure 6. Summarized graph of the four seasons of measurements. Total quantity of participants – 210.

We believe we are dealing with the real existence of electrocutaneous potentials allocation on the skin of the human body, which retain their values in the key control points – points-sources.

We have discovered a previously unknown phenomenon of the fact that the averages of every separate MZs conductivity displays constant stability over time, and the invariability of the mutual relative values of measured values, caused by skin-visceral relations of these points with the internal organs and functional systems.

Conclusions

We have noticed that the known methods of electro-diagnostics don't have the statistical confirmation. These known methods assume that the once-measured parameters of one person's MZs are statistically homogeneous data. However, according to the Acupuncture theory, each MZ reflects the state of a particular organ or organ system. Therefore, data cannot be considered as homogeneous when the measurements are taken only once. In this case such data and their descriptive statistics reflect the average condition of the skin, rather than each organ separately. Hence, statistically homogeneous data have to be an accumulated EDC MZs, obtained by measuring a group of people, or by repeated measurements of EDC MZs of the same human, crucially conducted over a period of time.

The regulations of the ECG processing may serve as an analogue to the data processing settlement of the EDC MZs measurements. It is known that each wave on ECG graph describes the electrical conditions of the exact part of the heart, but the parameter of all the waves is voltage.

EDC MZs reflect the current functional state of human, so their measurements and screening-diagnostics can be used to find the relative changes in the human condition in the course of any activity.

According to the results of the research, we have come to the following conclusions.

1. This work reflects the analyzing of common measurement methods for electrodermal conductivity in micro-zones; the ways of processing the results of measurements of the EDC of MZs by two worldwide methods. In the methods touched upon an important point - the statistical basis for the formation of a diagnostic conclusion.

2. It is described that the measurement method and the approach of statistical processing of the measurement results is controversial. The author suggests a different approach to the definition of statistically homogeneous EDC MZs dimensions.

3. Author showed that proposed processing data method is more informative than existing methods.

Author's suggestions for the measuring process EDC MZs and data processing:

a) The measurement of EDC at the points-sources is necessary to be performed using dry electrode.

b) Wettable electrode introduces additional noise in the measurement results. When it comes to the addition of the high conductivity resistor (electrolyte solution) to the equivalent circuit, it turns into a circuit with two parallel-connected resistors of significantly higher conductivity (electrolyte) than the conductivity of the controlled MZs. MZ conductivity in this case represents only a small part of the total conductivity.

c) Before starting the procedure, the device scale must be calibrated according to patient's particular skin electric qualities.

d) To receive comparable results, the MZ parameters have to be represented by the percepts of maximal scale range. To some extent, such registration method eliminates the differences in circuit design, in the case of measuring the MZ conductivity by different devices [8],[9].

e) The measurement results must be processed separately for every MZ (by columns according to Table 1). At this rate, it becomes statistically correct homogeneous data processing. This processing consists of calculating the average and confidence interval. We used graph for visualization the resulting averages. The confidence interval for every MZ is a statistically correct "norm corridor".

f) Graph makes it clearly seen that MZ's averages are non-chaotic, with high symmetric between "right" and "left" MZ parameters; mutual distribution of MZ parameters is stable over time. It is called "The phenomenon of stability of the average value of electrocutaneous conductivity in "points-sources of the meridians on the human body**"** [10].

g) It is statistically correct to say that a person has normal functional state if his/her MZs parameters fall within upper and lower confidence interval.

h) MZ parameters measured by the method we propose have the gender differences and reflect relative changes that appear as a result of dosed loading [11].

Taking into a consideration the stable, non-chaotic mutual relative allocation of the mean values of EDC MZs we can assume that MZs do exist; each of them has certain parameters (alike with the shape of the electrocardiogram) and they are effects of the skin-visceral relations. Probably we are talking about another regulatory system of the organism. [8], [12].

In order to establish the diagnostic rules it requires further accumulation of EDC MZs measurement results.

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