1.0 INTRODUCTION AND REVIEW OF LITERATURE

1.1 KNOWN FUNCTIONAL CONNECTIONS BETWEEN INTERNAL ORGANS AND SKIN

Various relationships between internal organs and the skin are known. Skin sensitivity, temperature, hydration, colour as well as electrical parameters may be changed by internal organ pathology. The correlation between psychological status and skin electrical resistance, known as the psychogalvanic reaction, is utilized in polygraph tests. The impact of endocrinological function and autonomic innervation of particular dermatomes on the skin electrical resistance is also well known. The electrical current perception threshold is influenced by many diseases.

Functional connections between skin and internal organs have been utilized in medicine for many centuries. Traditional African healers perform therapeutic procedures of so-called scarifications by making superficial incisions at particular skin areas close to a diseased organ. For example small cuts are made on the chest to alleviate bronchial asthma and around the stomach or the knee to reduce persistent pain in these areas.

In ancient times doctors in the Far East discovered that certain, even remote, skin spots become tender in case of disease of a particular internal organ. This tenderness disappears after the organ is cured. They presumed that a connection must exist between these spots and the related organs. Over time precise acupuncture maps were created and the points were therapeutically stimulated not only with needles but also with deep massage and heat (moxa).

More recently the French doctor, Nogier (19), working in North Africa, observed locals treating their domestic animals, including horses and camels, by cauterising particular zones on the animals’ ears. He examined human ear auricles and concluded that a particular area would become
tender when a related internal organ is diseased. In this way he created the first maps of auricular organ projection areas and originated the concept of the auricular homunculus. He also employed this discovery for therapeutic purposes by inserting small acupuncture needles at these points.

A number of so-called reflexive therapies are known in contemporary medicine i.e. therapies in which the skin is stimulated in order to obtain specific medical benefits, not related to the skin itself. These include acupuncture, acupressure, analgesic electrostimulation (TENS), low power laser therapy, magnet and electromagnetic therapy, reflexive thermotherapy (‘moxa’, cryotherapy) and ‘reflexology’ (reflexive massage of feet).
1.2 INFLUENCE OF ORGAN PATHOLOGY ON BIOELECTRICAL PROPERTIES OF THE SKIN: HISTORY OF INVESTIGATIONS

Many authors have investigated the effect of particular organ pathology on the electrical parameters of the corresponding skin areas. Croon and Overhof measured the electrical resistance and capacitance in strictly estimated skin areas (10,33,38). In this way they tried to localize the organic pathologies and secondary functional disorders as well as active primary focal infections. Wolkewitz evaluated electrical resistance, capacitance and temperature along certain lines on the patients skin, in different body areas (10,33,38). In this way he tried to localize the primary focal infection. Many authors supported the Galvanopalpation Test according to Gehlen and Standel as a complementary test in localization and evaluation of inflammation of certain internal organs (2,4,10,33,38). The skin area over the examined organ is stimulated with a weak direct current (at the individual perception threshold). If the organ is inflamed, flaring of the stimulated skin area is observed. Shimmel created the so-called Segmentary Electrogram (13,38). He examined the impedance of certain body regions by using eight 6cm diameter electrodes. On the basis of these measurements he tried to localize diseased organs and determine the kind of pathology.

A number of diagnostic methods were created using specific bioelectrical properties of acupuncture points (AP). Already in 1929 Dumie built a device which was supposed to localize AP on the basis of diminished electrical resistance in comparison to surrounding areas (33,38,39). Niboyet conducted investigations of various bioelectrical phenomena connected with acupuncture (18,33,38). He suggested that both AP and acupuncture meridians (lines connecting acupuncture points related to the same internal organs) display diminished electrical resistance and higher potential. Also Kreczmer, Dumitrescu and Nicolau indicated the difference between the resistance, capacitance and potential of AP and neighbouring skin areas (33,38,39). Podszibiakin stated that AP displayed tenderness, increased temperature and electrical potential (22,33,38,39). They are
also characterized by increased absorption of oxygen. “Biologically active points”, which include AP, display potentials 2-3mV higher than surrounding skin and these potentials rapidly increase with acute inflammatory diseases. In case of chronic diseases these potentials go down and after healing the potentials normalize. The author connected these changes with the function of the nervous system. According to the author, diagnostic results could be affected by external factors such as ionisation of the air, solar phase and psychological status of the patient. The number of “biologically active points” with diminished electrical resistance was much greater than the number of classical AP. Meerzon and Kotlar suggested that the electrical impedance of AP differs from other skin points (22,33,38). Rosenblatt based his electropuncture diagnostic method on the characterization of AP impedance across a wide range (24,33,38). Bratu, Prodescu and Georgescu created a diagnostic method based on the measurements of electric resistance and impedance of particular AP (1,33,38). By means of this method they attempted to identify disturbed “meridians”. According to these authors pathology was supposed to diminish the electrical resistance of AP. Similar changes in the electrical resistance of particular AP, connected to the character and location of pathological processes, were observed by Nagijeva, Dunajevskaja, Kassil and Ivanov (22,33,38). Some of these authors emphasized that changes in the electrical resistance of related AP occurred earlier than clinical symptoms of the disease, which indicated the possibility of early diagnostics and monitoring of the pathological process dynamics. Nikiforov and co-workers described the phenomenon of asymmetry in electrical conductivity characteristics of AP (33,38,39). In certain AP greater conductivity was observed for negative polarization of the measuring electrode and in others for positive polarization of the same electrode. Increased resistance for positively polarized measuring electrode was supposed to indicate pathology with an excessive amount of hypothetic “bioenergy”, while the reverse phenomenon accompanied a shortage of this energy.
Currently the most popular methods of electropuncture diagnostics, using corporal AP, include: ‘EAV’ by Voll (15,22,39,41) with modifications 'Vegatest' (13) and ‘B.E.S.T’ (6) as well as 'Ryodoraku' after Nakatani (12,22,39) with modification 'CITO' (22,39). ‘EAV’ is based on the hypothetic interaction between currents circulating in particular “meridians” and currents circulating in a measuring circuit. In order to identify the location of the “bioenergy disturbance” the author recommends measurement of electrical resistance of 172 selected points using a 1.5-2V measuring voltage. Nakatani utilized the hypothetic decrease in the electrical resistance of AP related to diseased organs. His diagnostic method Ryodoraku also evaluates “meridians” using round 1 cm$^2$ measuring electrodes. Nakatani believed that bioelectrical changes observed in AP are due to the influence of the sympathetic nervous system.

There is an increased interest in auricular electropuncture since publication of the map of auricular organ projection areas (OPA) by Nogier (19). On this map particular zones correspond to only one internal organ. According to Nogier auricular OPA related to diseased organs display reduced electrical resistance. Experimental localization of auricular OPA corresponding to particular organs was done on animals by Niboyet, Kvirchishwili and Portnov (22,33,38). However, there are significant differences in maps of auricular OPA prepared by different authors (5,8,16,17,19,22,39). Balaban and Rozenfeld suggested that auricular OPA exist due to anastomoses between the vagus nerve and other nerves supplying the ear auricle (22). Similar hypothesis were proposed by Quaglia-Senta (22) and Durinian (5). Durinian based his map of auricular OPA on detailed studies of the auricular innervation. He believed that diminished impedance in OPA is caused by constant stimulation of the convergence neuron by signals from a diseased organ (the convergence neuron is connected to both the internal organ and the related OPA). Welhover suggested that not only Head’s dermatomes, but also sensory organs can act as output terminals for afferent nerve signals (42).
As indicated, many authors have investigated the effect of particular organ pathology on the electrical parameters of the corresponding skin areas. Diagnostic methods based upon measurements of electrical potential, resistance and impedance of these zones have been proposed; however, their diagnostic accuracy has not been proven and reproducibility has not been consistent. A wide variety of measurement techniques and current parameters are used in the abovementioned methods. The results obtained often depend on perspiration, which is influenced by the patient's muscular tension, emotional condition, skin hydration, procedure duration, environmental temperature and humidity as well as the pressure of the measuring electrode (12,15,22,39). Furthermore, all these methods require additional analysis to draw any conclusions. Therefore these methods did not find widespread application in contemporary medicine and the authors' ideas did not create a unified and systematised scientific basis for the utilisation of bioelectrical skin properties for organ diagnostics.
1.3 INFLUENCE OF ORGAN PATHOLOGY ON BIOELECTRICAL PROPERTIES OF THE SKIN: OWN INVESTIGATIONS

My investigations of the electrical potentials of the skin surface (35-37) using an oscilloscope and various electrodes revealed that these potentials values vary widely ranging from 0 to 300 mV and their polarisation and value depend, among other factors, on: sweat gland activity, the type of electrodes used and the distance between the area under investigation and the reference electrode. Statistically significant differences in the electrical potential between the examined AP and other skin spots were not found. There was no statistical correlation between the electrical potentials of AP and the state of the respective internal organs.

Investigations of the electrical impedance of the skin (35-37) were done with a spring-mounted constant pressure Ag/AgCl dry point electrode (1 mm diameter) and a much larger wet reference electrode (also Ag/AgCl). Measurements were done at 10Hz (5 Vpp). It was found that a dense network of so-called low resistance points (LRP) exists on the entire body surface including the lips, where an absence of perspiration glands is observed. These are skin spots of diminished electrical resistance compared to the surrounding areas. The magnitude of the electrical impedance of LRP equalled $393\pm220$ kΩ and the impedance of the control points equaled $5.4\pm2.7$ MΩ. The difference in resistance between LRP and surrounding skin is greater for areas with thicker skin. The LRP are approximately 1-2mm apart. Histomorphological investigations revealed a statistically higher number of free nerve endings in skin samples taken from LRP compared with control samples (3).

The skin impedance depends significantly on skin thickness, which varies widely over the body. However, a relationship was found to exist between the skin impedance at various frequencies and the condition of internal organs related to the investigated skin areas (35-37). The phenomenon can
be seen in OPA, even though they may be remotely located from the related organ, or skin points corresponding to particular organs on the basis of classical acupuncture rules. The impedance of OPA/AP corresponding to diseased internal organs, measured with a point electrode was significantly higher across the measured range (10Hz-1KHz) than the impedance of OPA/AP corresponding to healthy organs. The results obtained were reproducible and not dependent on the patient’s skin perspiration and all factors which influence sweat gland activity.

Skin resistance characteristics were evaluated with an adjustable DC voltage supply, storage oscilloscope, and the electrodes described above (35-37). It was observed that the resistance of skin beneath the point electrode, when polarized negatively, undergoes a rapid resistance decrease of approximately two orders of magnitude, if the applied current is sufficient. After this reversible ‘breakthrough effect’ is obtained the skin exhibits rectification i.e. it behaves as a diode. With a negatively polarized electrode the resistance (after breakthrough) does not vary significantly for skin zones in the same region (e.g. on the ear auricle or on the abdomen). However, resistance values measured with a positively polarized electrode (after breakthrough) may vary significantly: the degree of rectification at a skin zone related to a specific internal organ displays a high statistical correlation with the state of health of that organ. The resistance measured with a positive polarization can be five times greater than the resistance measured with a negatively polarized electrode at the same voltage, if the related organ is severely damaged. The results of skin resistance measurements obtained by means of the method described above are consistent and reproducible, as in the case of skin impedance measurements. However, a slight correlation with the pressure of the measuring electrode was noticed (up to 5% of the result value). Skin resistance measurements taken before the ‘breakthrough effect’ did not demonstrate any diagnostic value and had a much greater dependence on pressure.
These findings, concerning the relationships between the state of health of internal organs and the skin’s bioelectrical characteristics, created the groundwork for a new, non-invasive diagnostic method – organ electrodermal diagnostics (OED) (25-27,31,33,38). The location of the skin zone, where a high degree of rectification and increased impedance is observed, indicates which particular organ is diseased. The degree of rectification or difference in impedance indicates the extent of the pathological process within this organ.

The OED examination involves placing a wet reference electrode (2 cm$^2$) on any area of the patient's skin, e.g. on a hand, and placing a dry point electrode on the skin area corresponding to the particular organ. The point electrode is polarized negatively and the potential is increased until the “breakthrough effect” is observed. The skin resistance is then measured. The polarity of the point electrode is inverted (same voltage but positively polarized) and a second resistance measurement done. The ratio between these two measurement values, taken from the same skin point, is calculated using the second measurement as the denominator. Finally this ratio is converted to a percentage reflecting the disease intensity: ‘HEALTHY’ (0-40%), ‘WITHIN NORMAL LIMITS’ (41%-60%), ‘SUBACUTE PATHOLOGY’ (61%-80%), ‘ACUTE PATHOLOGY’ (81%-100%).

In case of thick dry skin e.g. plantar region, where obtaining of the breakthrough effect is more difficult, an AC based modality can be used. However, the use of impedance measurements for organ diagnostic purposes requires separate calibration for different kinds of skin, to determine a point of reference (32). This must be compared with the impedance value obtained with a measurement electrode in order to obtain a diagnostic result. The results can be displayed in a similar way as for DC measurements i.e. as a percentage of disease intensity.
Electrical resistance investigations of the ear auricles were carried out by means of prototype OED devices in patients who were clinically diagnosed with gastric and duodenal ulcers (28). These showed accurate locations of stomach and duodenum auricular projection areas and demonstrated the usefulness of OED in monitoring peptic ulcer disease. Similar investigations performed on patients suffering from viral hepatitis allowed for the exact localization of liver projection areas and also confirmed the possibility of monitoring the progression of viral hepatitis by means of OED (29). OED examinations of auricular projection areas of the gall-bladder, appendix and the stomach performed during successive stages of general anaesthesia and surgical intervention (30) proved a statistically significant increase in the degree of rectification at related skin zones during direct surgical manipulation of these organs.

Two comparative double-blind clinical trials (31,33) confirmed the ability of OED to detect as well as estimate the extent of pathologies of the oesophagus, stomach, duodenum, pancreas, biliary tract, colon, lungs, kidneys and urinary tract. Detection rates, sensitivity rates, specificity rates, predictive value rates were approximately 90% in both trials (statistically significant difference between the total sum of true and false results: P < 0.0001).

The OED results were affected neither by the type nor the aetiology of disease, i.e. OED cannot directly explain the cause of pathology. The results obtained were consistent and reproducible and not dependent on the patient’s skin perspiration and all factors which influence sweat gland activity. No side effects of the OED examinations were observed.
1.4 SHORTCOMINGS OF EXISTING RESEARCH

Although the electrical phenomena of the skin described in the previous section have been confirmed clinically, the resistance and impedance values involved have not been characterized statistically. Therefore, in order to determine the optimal electrical parameters for OED, further research is needed. In addition, a need exists for an automated user-friendly device that could simplify the diagnostic procedure.