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DERMATOGLYPHS AND THEIR IMPORTANCE FOR DIABETES PREDICTION. A REVIEW FROM THE LITERATURE

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Diabetes is considered a major global public health problem. The high prevalence of diabetes, as well as the upward evolution curve, is a feature of modern society, which can be appreciated by the accelerated growth of the GDP of the countries, starting with the middle of the twentieth century when the phenomenon was identified in the USA, later reaching the developed European countries, but also other countries such as Japan or Australia. The further increase in the prevalence of diabetes along with the change in lifestyle has led to the idea that most of this increase can be prevented, especially in cases that have been shown to have an increased risk for diabetes, with the discovery of associated genes, on the one hand with type 1 diabetes, on the other hand with type 2 diabetes. Following the Hippocratic urge that to "prevent is better than to treat", the prevention of diabetes has become one of the major goals of modern medicine. The unique character of dermatoglyphs, implies the possibility that among the many dermatoglyphic elements (models) that we will describe later, some of them may indicate the predisposition to different diseases. Leaving aside serious genetic diseases, which are usually monogenic defects and are associated with malformations or severe degenerative diseases that appear in childhood and which manifest dermatoglyphically through important and specific changes to each disease, expect us as in polygenic diseases as it is diabetes that may have some phenotypic characteristics of dermatoglyphs, able to predict to a greater or lesser extent the occurrence of diabetes.

Keywords: dermatoglyphs, diabetes, distal phalanx, prediction, palm.

INTRODUCTION

Diabetes is considered a major global public health problem, with an estimated global prevalence of 8.3% in 2013, which is expected to grow to an alarming figure of over 590 million people affected by 2035[1]. Type 2 diabetes mellitus (T2DM) accounts for more than 90% of all diabetics[2]. It is a multifactorial polygenic disorder that involves several endogenous and exogenous risk factors[3,4].

Type 2 diabetes is a disease with a well-defined genetic component, but in its etiological complexity the contribution of non-genetic components are highlighted[5]. A number of prenatal environmental pathogens have been identified as possible risk factors for type 2 diabetes, including: mother's type of nutrition, objective difficulties or stress related to natural disasters, the season of birth (related to vitamin D metabolization) or melatonin), urbanization, drugs such as corticosteroids during pregnancy, pesticide use, etc.[6–9]

One of the major goals of current diabetology is the prevention of both type 1 diabetes and type 2 diabetes.

The high prevalence of diabetes, as well as the upward evolution curve, is a feature of modern society, which can be appreciated by the accelerated growth of the GDP of the countries, starting with the middle of the twentieth century when the phenomenon was identified in the USA, later reaching the developed European countries, but also other countries such as Japan or Australia. After the Second World War, the division of Europe into two different zones, one considered as the capitalist zone in the west and the other as communist in the east, the incidence and prevalence of diabetes has experienced a much greater development in the western countries than

in the eastern countries, a fact attributed to greater access to abundant food in the first group of countries compared to eastern countries. This finding led to the conclusion that besides the genetic factor known since the 19th century as being present in all populations, the second important factor, the one related to the lifestyle and especially the high availability of food, especially the high processed food, was considered the most important environmental factor. This was well confirmed after 1990 when the western lifestyle was adopted by the eastern countries, with the increasing prevalence of diabetes.

The further increase in the prevalence of diabetes along with the change in lifestyle has led to the idea that most of this increase can be prevented, especially in cases that have been shown to have an increased risk for diabetes, with the discovery of associated genes, on the one hand with type 1 diabetes, on the other hand with type 2 diabetes. Following the Hippocratic urge that to "prevent is better than to treat", the prevention of diabetes has become one of the major goals of modern medicine.

However, this implies a prerequisite, namely the identification of the risk for the occurrence of diabetes, using the different risk modules: a) the clinically detected risk (family inheritance, the change of anthropometric disorders, etc.); b) the genetic risk, based on the identification of the genes found associated with the two phenotypes of diabetes (the autoimmune and the non-autoimmune), whose number exceeded 100 for both, even though more than half of them have a very low significant contribution in diabetes risk assessment; c) the biochemical risk (identification of biochemical and hormonal markers, appreciated differently for type 1 and type 2 diabetes respectively, whose number is increasing).

Type 1 and type 2 diabetes are two diseases that have different causes, but the predisposing genetic substrate is involved in the pathogenesis of both. Only genetic changes are not capable of triggering the disease, triggers in the external environment play an essential role in the phenotypic manifestation of the disease for both types of diabetes.

Type 1 diabetes, also known as juvenile diabetes, is an autoimmune disease that currently affects millions of people around the world, with an incidence of striking growth rates. According to the National Health Strategy 2014–2020, Romania ranks 9th in the EU as a prevalence of diabetes.

Type 2 diabetes called "cancer of the 21st century" is a disease with a worrying increase in prevalence in the last half century. The western lifestyle characterized by lack of physical activity, high fat diet and high obesity rate led to this alarming change in genetic predisposition. According to the European Association for the Study of Diabetes (EASD), approximately 195 million people suffer from diabetes worldwide and this number is expected to increase to 500 million by 2010.

The numerous dermatoglyphic models result from the association of a certain architecture of the many genes that encode the collagen molecules that are the basis of the generation of skin and plant skin relief accidents. A certain relief pattern is also identified in the skin of the other areas of the huge skin surface. This is known by surgeons, in case of an incision on the thighs, legs, chest or abdomen, the incision is made along the longitudinal paths of this rarefied dermatoglyph model, as an incision that crosses them is followed by a more prominent scar.

The unique character of dermatoglyphs, implies the possibility that among the many dermatoglyphic elements (models) that we will describe later, some of them may indicate the predisposition to different diseases. Leaving aside serious genetic diseases, which are usually monogenic defects and are associated with malformations or severe degenerative diseases that appear in childhood and which manifest dermatoglyphically through important and specific changes to each disease, expect us as in polygenic diseases as it is diabetes that may have some phenotypic characteristics of dermatoglyphs, able to predict to a greater or lesser extent the occurrence of diabetes.

When we talk about diabetes, we consider the heterogeneity existing within this large syndrome, which includes, on the one hand, the rare monogenic forms of diabetes (which together do not exceed 1% of the total number of diabetics), and on the other hand the polygenic forms, which in turn they are part of several clinico-pathogenetic phenotypes, of which two can be considered as distinct: the autoimmune type, now called type 1 diabetes (with a subtype that has been called the intermediate type of diabetes – IDM, also known as the form LADA-Latent Autoimmune Diabetes in Adults) and the non-autoimmune type of diabetes called type 2 diabetes, which in turn has two sub-phenotypes, one (most common) associated with obesity and another (less common) occurring in normal-weight persons.

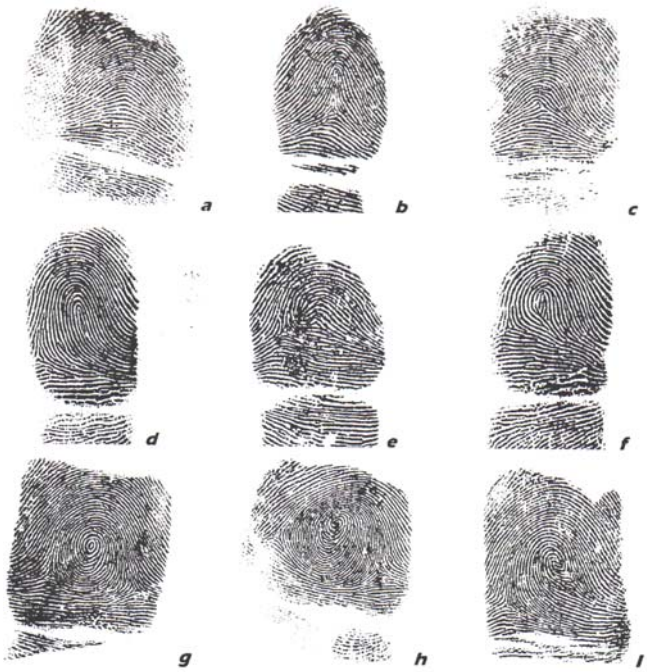

Figure 1. The main types of models on the distal phalanx: a, b, c-arc, d, e, f-loop, g, h, i-verticil (Adapted by Lidia Cotutiu. Dermatoglyphs in medical and judicial practice, Ed. Iasi, 1998, p. 20).

There are 300 genes associated with different diabetes phenotypes, and risk scores calculated so far do not greatly contribute to risk assessment. A higher value is provided by biochemical, immunological and hormonal indicators, whose value is higher in identifying the different phenotypes of diabetes, depending on the pathogenic mechanism that expresses on the one hand the β-cell function, and on the other hand the immunological function. From their association in different proportions the different phenotypes of diabetes also result.

As all risk scores have advantages and disadvantages there are other information of this kind that can be used. Lately, there has been an increasing interest in the study of dermatoglyphs, as an indicator of genetic predispositions, including diabetes. Selecting some of the qualitative or quantitative aspects of dermatoglyphs to find information on diabetes should be done with care. Because diabetes is a heterogeneous disease as a pathogen and as a clinical expression we expect this heterogeneity to be found in the dermatoglyphs study as well.

The interest for the study of dermatoglyphs in diabetes is a topic of interest in literature. Numerous researchers have published studies addressing this topic, the results indicating a clear correlation between diabetes and certain dermatoglyphic patterns. In 2016, these causal evidences between dermatoglyphic changes and diabetes both type 1 and type 2 materialized through a computer system for analyzing the number of digital ridges from the homologous fingers[10] (Fig. 1).

Given the importance of the study of dermatoglyphs in the prevention and early identification of diabetes, we illustrate in the literature the points of interest that have been identified in different recent studies or in the last century, but with significant results regarding the dermatoglyphic changes and their correlation with diabetes. We resume the sharing of the dermatoglyphic picture, with the qualitative and quantitative description of the dermatoglyphs, exemplifying from the cited studies the results with statistical significance.

LITERATURE REVIEW

This section highlights the qualitative aspects of the dermatoglyphic picture presented in the specialized literature.

For a correct and detailed analysis of the palmar dermatoglyphs it is necessary to read the whole dermatoglyphic picture. Initially the evaluation of the palmar models must take into account the configuration of the dermatoglyphic pattern at the level of the distal phalanges.

The classification used in this paper as well as in the practice of reading the dermatoglyphs introduced in this study is that of the French author

Monique Lestrange, who divides the dermatoglyphs digitized into 18 subtypes with a clear highlighting of the ulnar and radial orientation forms[11,12].

Thus using the PubMed, Medline, and Google Scholar databases, we have selected a number of scientific articles which discuss the possible associations between certain frequency changes of models present in the distal phalanges of the patient's hand and the clinical manifestation of diabetes.

A. Fingers

Using the initials from the international nomenclature, we can group the patterns encountered at the level of the distal phalanx as follows (Fig. 2):

– Arch (A), Piniform arch (T), Loop spring (AL)

– Loop (L), Rachetoid loop (LW), Wavy loop (Ln)

– Concentric vertex (W), with spiral center (Ws), with ellipsoidal center (Wel), "pocket" (WL), double center (Wd)

– Exceptional (Unk)

The radial orientation of the model is indicated by r (eg rL, rW).

A study dealing with the problem of reading digital models and the use of this information and the possible earlier diagnosis of people at risk of developing diabetes is discussed in 2005 by two Romanian researchers Ana Tarca and Elena Tuluc[13] The study was carried out on a group of 133 subjects with type 1 diabetes (58 men and 75 women), of which 58 are children and adolescents aged between 4 and 18 years and with a disease onset between 2 and 17 years. 75 are adults and the elderly between 24 and 79 years old, at which the disease started between 22 and 76 years old. In 51.12% of cases, type 1 diabetes is primary insulin-dependent and 48.88% secondary insulin-dependent. It is found that both patients with a juvenile onset of diabetes and those with a late onset of the disease show significant changes in the digital dermatoglyphic picture. The changes are present in both male and female subjects, on both hands but especially on the left. In conclusion, the authors stated that the environmental factors from the prenatal life act during the postnatal period, being responsible for the clinical onset and manifestation of the disease. The results of the study support a possible use of dermatoglyphs (a less expensive and easily reproducible test in any of the stages of postnatal life), as a useful marker, together with metabolic, immunological and genetic markers, in predicting a possible population-level diabetes risk[13].

As shown in this study, specific to type 1 diabetes are: a substantial reduction in frequency – loops (L), – with a significant increase in frequency of whorls (W) and arches (A); attenuating the bimanual differences for all three digital models, until they are completely erased; an inverse order of distribution of the three models on the fingers, but only for the last three positions in the classical distribution scheme in the decreasing order of their frequency; the presence on the fingers – especially on I, II and III – of structurally complicated models (with more than two triads) of the type TL, LP, CP etc., or the combination of two models on the same finger (A + L, A + W, L + W)[14]; a significant increase in the frequency for the radial orientation of digital models (A, L, W)[15]. This frequency is mostly fulfilled on fingers II and III, but is often encountered on fingers I and IV, positions that suggest an amplification of the pathological meanings; The unexpected increase in the frequency of monomorphism in both the left and right hand, with higher values for the female series, as an expression of a more intense affection of this series compared to the male one. Most of the digital distortions highlighted that are present in both the male and female series reach higher percentages on the left hands of the affected persons (as they occur in other severe genetic diseases)[16]. These findings of changes in digital dermatoglyphs could help to design markers to detect diabetes risk in the population at a very low cost. The authors' conclusion sheds new light on the screening of type 1 diabetes. The appearance of these markers, prior to the clinical manifestation of the disease, makes it possible to use them in insulin-dependent diabetes prevention programs[13].

Another study, published in 2013, discuss the identification of quantitative parameters of dermatoglyphic analysis and qualitative parameters such as the model on the distal phalanges[17], as presented previously. They used handprints from 100 patients (50 men and 50 women) diagnosed with type insulin-independent diabetes (type 2 diabetes) and 100 normal fingerprints, from healthy persons (50 men and 50 women) as a control group. The patients were diagnosed by the doctor and were undergoing drug treatment. Subjects in the control group were selected on certain criteria, over 45 years of age, with no family history of diabetes and normal blood sugar level. Dermatoglyphs were read using a magnifying glass. In this paper four parameters were studied, these include the dermatoglyphic models of the distal phalanx, angle atd, and line c.

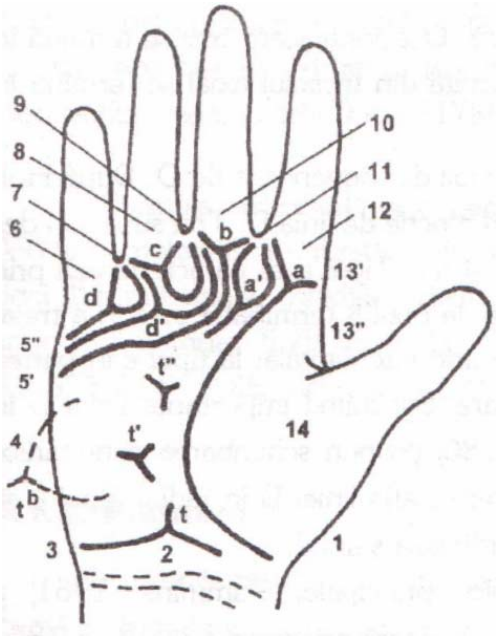

Figure 2. The palm: the main triads and the numerical area value for calculating the index of the main lines (Adapted after Lidia Cotutiu. Dermatoglyphs in medical and judicial practice, Ed. PsihOmnia, Iasi, 1998, p. 27).

In the fingers, the ulnar loops in the diabetic and non-diabetic were 2.60, respectively 5.89. This difference was statistically significant ($p < 0.05$). The whereabouts in diabetics and non-diabetics were 5.78 and 2.84 respectively. This difference was significant ($p < 0.05$). The radial loop and the arches showed no significant difference between diabetics and non-diabetics.

In 2018, Sehmi publishes a complex article on dermatoglyphs, which takes into account several studies published so far[18]. The author's conclusion is that the dermatoglyphic investigation is absolutely cost-effective and does not require hospitalization and can help predict the phenotype of possible future diseases. Several studies conducted on different populations have identified a significant correlation between different patterns of finger-printing and diabetes, however, the type identified varies from one geographical region to another, and this may be due to racial dermatoglyphic differences, which differ from one population to another. However, after a competent analysis,the results of the different authors[18] seems to agree at a certain level. Possible reasons why not all study results correlate with each other could be, concludes Sehmi, small sample size, incomplete diagnoses, inadequacy of control group, statistical errors and lack of openness of subjects. Although the study of dermatoglyphs does not yet play a role in clinical diagnosis, it may serve as a way to select individuals from a larger population for further investigation, to subsequently confirm or exclude diabetes[18].

a. Arches

Following the dermatoglyphic structures that qualitatively describe the dermatoglyphic picture, starting with the description of the drawings on the distal phalanx, regarding this drawings, there are different research studies in the literature.

Panda *et al.* (2004)[19] showed an increase in diabetes for both sexes, but Sant *et al.* (1983)[20] and Rezal *et al.* (1999)[21] showed an increase in arches only for diabetic women compared to the control group. No significant increase was observed for men and women in the study by Rajaniganda *et al.* (2006)[22]

Mandascue *et al.* (2000)[23], Nayak *et al.* (2015)[24]; Umana *et al.* (2013)[25], Sharma and Sharma (2013)[26] and Sachdev (2012)[27] reported that diabetics have significantly lower arches than subjects without diabetes. Both male and female diabetics showed a significant increase in the frequency of loops and arches and a decrease in the frequency of whorls, especially in the middle finger. Bala *et al.* (2015)[28] showed a significant decrease in the number of arches on the right hand of male diabetics and on the left hand of female diabetics. Brute *et al.* (2013)[29] showed that the percentage of springs was higher in men and women diabetic compared to the control group and that the difference observed in the male group was not statistically significant. The study by Marera *et al.* (2015)[30] showed a significant increase of the archiform patterns in the diabetic patients compared to the control group. However, in some

fingers, such as the ring finger, the arch pattern was completely missing in both groups. The study of Roshani *et al.* (2016)[31] and Padmini *et al.* (2011)[32] showed more arches in women compared to men in the right and left hands, while Sengupta and Borush (1996)[33] showed more arches in diabetic men.

b. Radial loop

Regarding the radial loop, Ravindranath *et al.* (1995)[34], Panda *et al.* (2004)[19] found the increase of the radial loop in both sexes in the group of diabetic patients. Bets *et al.* (1994)[35] showed a decrease in the incidence of the radial loop in diabetics, as did Verbov *et al.* (1973)[36]; Sant *et al.* (1983)[20]; Rajnigandah *et al.* (2006)[22]; Mandascue *et al.* (2000)[23], Nayak *et al.* (2015)[37] found no statistically significant difference in the radial loop pattern in diabetics and the control group.

c. Ulnar loop

Panda *et al.* (2004)[21] ,Ravindranath *et al.* (1995)[34], showed an increase in ulnar loop patterns in both sexes in diabetics, but Sant *et al.* (1983)[20] showed a decrease in the ulnar loop in both sexes. Nayak *et al.* (2015)[37] showed no significant difference in diabetics from the control group.

d. Whorls

Sant *et al.* (1983)[20] observed a significant increase in the frequency of whorls in both genders among diabetics, but Ravindranath *et al.* (1995)[34] and Panda *et al.* (2004)[19] showed a decrease in the number of whorls in diabetics compared to the control. Rajnigandha *et al.* (2006)[22] and Mandascue *et al.*. (2000)[23] showed no significant difference in diabetics and control. A study by Akshailekshmi and Anandaranl (2016)[38] showed that the frequency of whorls was significantly higher in diabetics, and the frequency of ulnar loops and arches was significantly lower in both male and female cases. Sengupta *et al.* (1996)[39] found that there is an increased frequency of whorls in male diabetics. Srivastava and Rajasekhar (2014)[39] found that there is an increased frequency of vertex pattern in both sexes. In Sachdev's (2012)[40] study, both male and female diabetics showed a significant increase in the frequency of loops and arches and a decrease in the frequency of whorls, especially at the finger III. In the study by Roshani *et al.* (2016)[31] whorls were most commonly found in the right and left hands of diabetic women, which was similar to Khan *et al.* (2009)[41], Sant *et al.* (1983)[20], Sengupta *et al.* (1996)[39]. This was different from the study by Karim *et al.* (2014)[42] (whorls were reduced, while loops were more), as well as Ravindranath *et al.* (1995)[34] and Verbov *et al.* (1973)[36] showed a low number of vertebrates in diabetics compared to the control group.

e. Palms

The palm is divided into 5 areas: hypotenuse, tenar/ I interdigital area and the other three interdigital areas I2, I3, I4 that form the upper region, from the base of the fingers (Figs. 3 and 4).

The configurations in the tenar and the first interdigital area, in a very large proportion (85%) are characterized by a smooth pattern, in which the parallel papillary ridges are arched, this model can be interrupted by the appearance of different oriented ridges, called vestiges (V)[43].

Configurations in the second, third, and fourth interdigital areas (from the base of the fingers) are characterized by the radiations of the main triads denoted a, b, c, d, from which the main lines of the palm A, B, C, D start[44].

The configurations in the hypotenuse area are the most complex. The most common configuration is the ulnar arch, called "free field"[13], and the radial opening loop (Lr), the ulnar loop (Lu), or the carpal (Lc), the radial or carpal opening arcs, as well as the simple or composite vertices may also appear.

The Romanian researcher Ana Tarca studied besides the association between type 1 diabetes and the patterns in the distal phalanges[13], the possible association between diabetes and the frequency of the models in the palm compartments. This study, conducted in 2006, was carried out on a batch of 190 patients (60 men and 130 women) diagnosed with type 2 diabetes, between the ages of 40 and 82 and with a disease onset between 35 and 80 years. The results obtained were studied in comparison with those found by the same author, in a previous study in patients with type 1 diabetes. A palmar dermatoglyphic picture with a large pathological load, suggestively illustrated by 10 distortions or anomalies with profound medical significance[44]. The author notes a similarity of dermatoglyphic changes between patients with type 1 and those with type 2 diabetes. Thus, the author asserts these changes can serve as "markers" in the early diagnosis of people at risk for type 2 diabetes.

The author performed a complex and meticulous dermatoglyphic analysis shown in Table 1, observing 10 anomalies present in patients with diabetes (Radial arch and ulnar Lat in hypotenuse space, tt't" and tt't"tu and presence of triradius t0; drawing very emphasized in the tender space, etc.) However, there were 2 important deviations from normal condition, they consisted in the sensitive decrease of the model

frequency in the interdigital space IV which led to the change of the position of this compartment in the classical distribution formula in the sense: III> Hp> IV> Th / I> II instead of IV> III> Hp> Th / I> II[44].

The author concludes that these pathological changes are correlated with the results from the specialized literature and could be used in medical practice for the early diagnosis of type 2 diabetes.

Table 1

Comparative dermatoglyph abnormalities in T2DM versus T1DM (after Tarca A. Dermatogliphics in type 2 diabetes mellitus (T2DM) or nonindependent. Journal of preventive medicine. 14: 60-70, 2006)

Palmary anomalies	Affected people	Only on the left palm	Only on the right palm	On both palms	Total carriers
A^R	T2DM	6.66	73.33	20.00	7.89
in Hp	T1DM	7.69	76.92	15.38	9.77
L^U	T2DM	31.43	42.86	25.71	18.42
in Hp	T1DM	44.83	31.03	24.13	21.80
tt't'';	T2DM	19.51	53.66	26.83	43.16
tt't''t^u, etc.	T1DM	14.51	38.71	46.77	46.61
T11 + T12	T2DM	46.37	20.29	33.33	36.31
	T1DM	58.18	20.00	21.82	41.35
t_o	T2DM	41.66	33.33	25.00	6.31
	T1DM	100.00	-	-	1.50
Dense and very	T2DM	25.00	15.79	59.21	40.00
dense network in Th/I	T1DM	17.46	17.46	65.08	47.37
a-b< 21 mm in F	T2DM	41.86	20.93	37.20	22.63
and 24 mm in M	T1DM	16.66	41.66	41.66	36.09
Cx	T2DM	48.11	23.58	28.31	55.80
	T1DM	39.39	21.21	39.39	49.62
Co	T2DM	34.88	32.56	32.56	22.63
	T1DM	52.94	11.76	35.29	12.78
Transverse	T2DM	36.11	27.77	36.11	18.95
palmary sulcus	T1DM	46.15	26.92	26.92	19.55

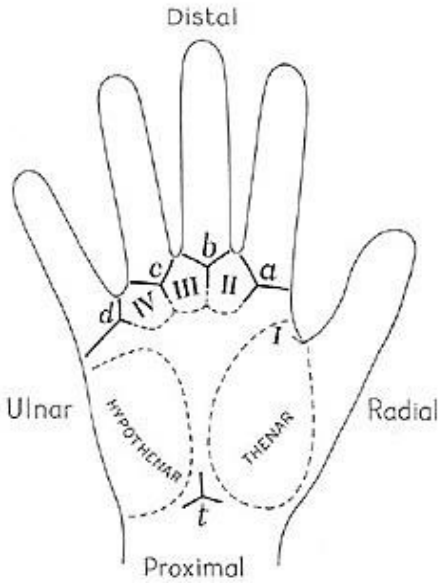

Figure 3. Palma: Zonal division
(Retrieved from Srivatsava S., Burli S. A study of palmar dermatoglyphics in type 2 diabetes mellitus in a Bangalore-based population. Indian Journal of Clinical Anatomy and Physiology, 6: 118-125, 2018).

Table 2

Quantitative parameter analysis (after Srivatsava S., Burli S. A study of palmar dermatoglyphics in type 2 diabetes mellitus in a Bangalore-based population. Indian journal of Clinical anatomy and Physiology, 6: 118-125, 2018)

Parameter	Male		Female	
	Cases	Controls	Cases	Controls
	Mean S.D.	Mean S.D.	Mean S.D.	Mean S.D.
a-b Count Right	29.9 6.2	27.2 5.2	28.1 5.6	29.1 7.3
a-b Count Left	31.3 6.3	28.7 5.0	28.7 6.4	29.9 6.8
atd Angle Right	41.0 8.0	40.3 7.5	40.9 7.0	41.4 6.6
atd Angle Left	41.4 7.4	41.2 6.7	41.4 7.4	42.4 7.5
Distal Deviation of t Right	7.1 1.8	6.6 1.7	16.7 10.3	16.6 11.0
Distal Deviation of t Left	7.1 2.0	6.3 1.8	16.9 10.2	11.1 8.2
Breadth Ratio Right	6.8 0.9	6.7 1.0	6.1 1.1	6.0 1.0
Breadth Ratio Left	6.9 0.9	6.8 1.1	6.0 1.0	5.9 1.1
Main-Line Index Right	14.6 1.8	14.7 1.7	14.4 1.9	14.5 1.8
Main-Line Index Left	13.7 2.0	13.1 1.8	13.3 2.1	13.2 2.0

B. Quantitative aspects of dermatoglyphs as evidenced by specialized studies

They are represented by: the intensity of the models, the number of papillary increases or the distance in millimeters between two landmarks, the number of triads.

The intensity of the models is determined according to the number of triads present. Thus an area can have intensity – and in conclusion the value 0, when it has an arc, the value 1 when a loop appears, the value 2 when a whirl appears[45].

The sum of the digital ridges is used to indicate the size of the model. It is calculated by counting the ridges along a straight line between the radius and the center of the model and represents the sum of the papillary ridges, noted (RC). The triradial point and the central point are excluded from the count. The whorls, which have two triads, whether they are mno or double-centered, have two RCs. The arc has RC = 0. The total sum of the digital ridges (TFRC) represents the sum of the papillary ridges of the distal phalanx models including the RC of the loops and the largest sum of the two-dimensional models.

The absolute sum of ridges (AFRC)[46] is the sum of all ridges on the delto-central line. Recently published studies deal with this way of characterizing the models, bringing new information about the ability of dermatoglyphs to predict diseases[47].

A study that besides the discuss of digital models also took into account the quantitative aspects of the dermatoglyphs was published in 2018[48] in India. It included 75 men and 75 women with type 2 diabetes, with a positive family history of diabetes and 75 men and 75 non-diabetic women as witnesses, with no family history of diabetes. The prints were recorded by the ink method and analyzed for qualitative and quantitative parameters.

The authors of this study presented a complete and complex analysis of the entire dermatoglyphic picture, studying rigorously qualitatively and quantitatively the parameters characteristic of the palmermal dermatoglyphs. The statistically significant results show a significantly higher incidence of spiral swirls on both hands, and in the control group, both sexes showed a higher incidence of loops on both hands. In men, the intensity of the model, TFRC (the total sum of the digital ridges) and AFRC (the absolute sum of the ridges) of both hands were significantly higher in

diabetics. In women, the intensity of the model, AFRC, MFRC of both hands and TFRC of the right hand were significantly higher in diabetics. The left hypotenuse area showed a significantly higher incidence of open fields in the women in the control group. The fourth straight interdigital area showed a significantly higher incidence of open fields in female diabetic persons. Scores for the number of ridges ab, angle atd, distal deviation of point t, ratio of width and index of the main line were not statistically significant. The authors conclude that dermatoglyphs can be used for early and inexpensive screening of people at risk of type 2 diabetes, the indices identified being applicable to a population in southern India, Bangalore, which is accredited as the "diabetic capital of the world." This study was conducted on a small number of patients (75 men and 75 women), so even the authors conclude that larger population studies are needed to standardize the parameters and translate the results into clinical practice and public health[49].

a. Position of the axial triadius. The angle atd.

By joining a triadius and respectively d with t, the angle atd is obtained. When there are multiple t – triadiuss, the most distal is considered. Tritadius t usually occurs in the proximal part of the palm at the junction of ridges in the tender and hypotenuse areas. Sometimes there are two or even three axial triadius on a palm, marked differently: t – the axial triradius in proximal position, at the wrist, t' – the triradius in the center of the palm and t – in the intermediate position between the two described above.

To avoid certain errors, the fingerprint is made with the fingers close together. The disadvantage of this method is that, with the age of the palm, it grows more in length than in width, and the angle atd decreases[50].

A study conducted in 2014 that addresses this problem, measuring the angle atd, and correlating it with possible implications in identifying patients at risk of developing diabetes is that of the researchers Trivedi PK *et al.*[51]. In this study, dermatoglyphic patterns were taken for 100 cases (50 men, 50 women) of non-insulin-dependent diabetes mellitus between the age group of 40–75 years. 100 normal healthy people without non-insulin-dependent diabetes were included in the study as controls. The dermatoglial fingerprints from this study were taken by the Ink method. As a study parameter in the case of this research, the Atd Angle was measured (Fig. 5).

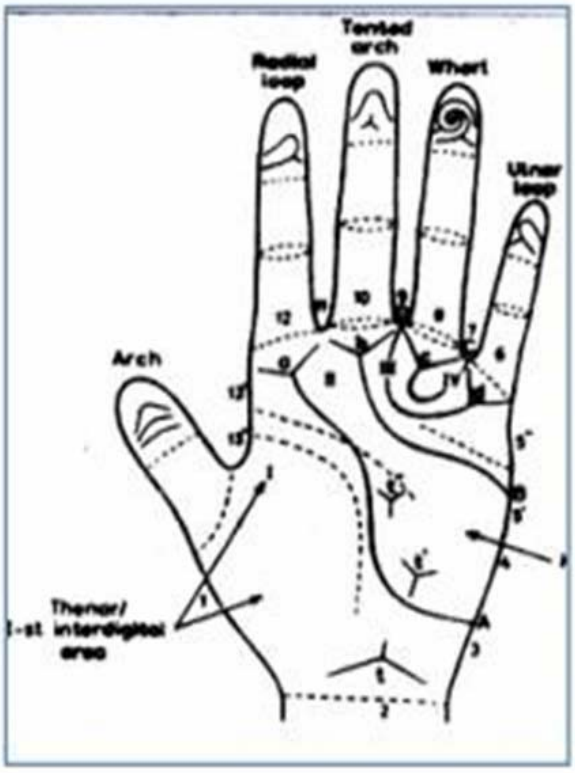

Figure 4. Palma: Highlighting the triads t, t', t''.
(Retrieved from Srivatsava S., Burli S. A study of palmar dermatoglyphics in type 2 diabetes mellitus in a Bangalore-based population. Indian Journal of Clinical Anatomy and Physiology, 6: 118-125, 2018).

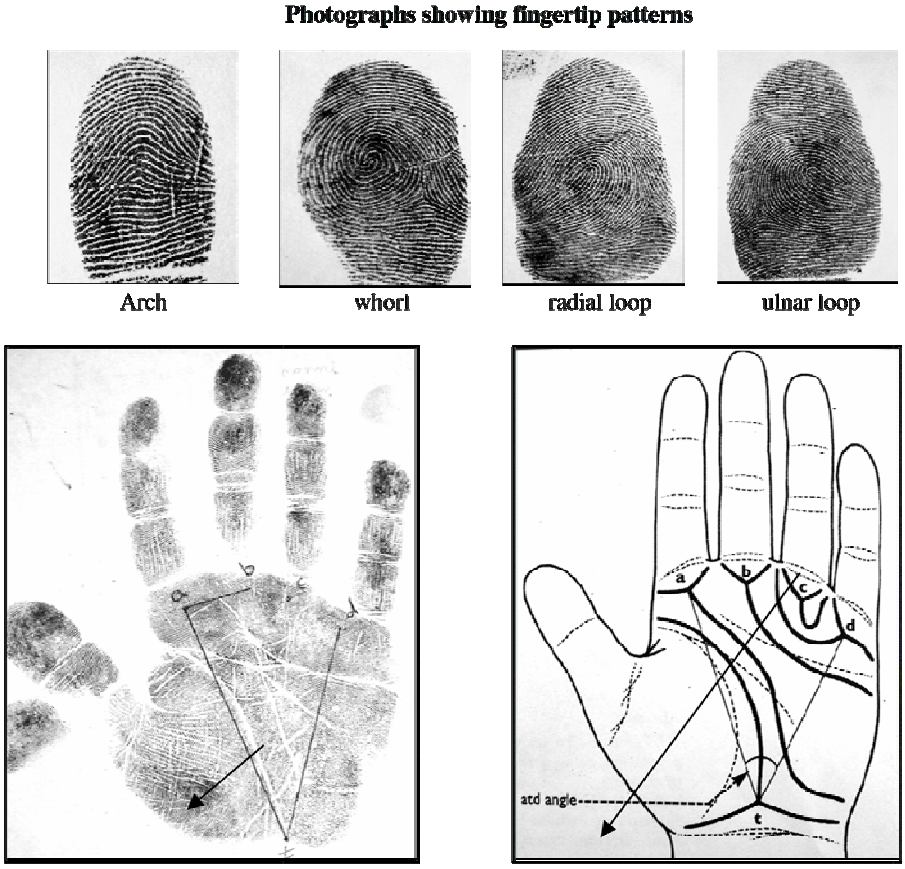

Figure 5. Angle atd (Retrieved from Pathan JM, Rubeena N. Variations of Dermatoglyphic Features in Non Insulin Dependent Diabetes Mellitus. International Journal of Recent Trends in Science and Technology, 8: 16-19, 2013).

Table 3

Comparative presentation of the results of several studies regarding the measurement of angle atd, (taken from Trivedi PK, Singel TC, kukadiya U, *et al.* Correlation of atd angle with non-insulin dependent diabetes mellitus in Gujarati population. Journal of research in medical and dental science. 2, 2, 2014)

Researcher	Sample Size	Sex	Side	Mean Angle(°) in Cases	Mean Angle(°) in Controls	P Value	Remarks
Gabriel SO and Babajide MO (2004)[5]	49 Cases 52 Controls	M	R	40.20	40.50	<0.05	S
			L	40.60	39.00	<0.05	S
		F	R	36.10	41.60	<0.05	S
			L	38.90	43.00	<0.05	S
Rajnigandha V *et al.* (2006)[6]	112 Cases 142 Controls	M	R	52.51	44.26	<0.001	HS
			L	52.13	43.60	<0.001	HS
		F	R	55.57	45.12	<0.001	HS
			L	58.08	45.64	<0.001	HS
		M+F	R	53.85	44.73	<0.001	HS
			L	54.73	44.70	<0.001	HS
Padmini MP *et al.* (2011)[7]	200 Cases 200 Controls	M	R	39.15	41.68	>0.02	NS
			L	41.67	40.92	<0.4	NS
		F	R	42.61	42.32	<0.7	NS
			L	40.06	43.25	>0.01	S
		M+F	R	42.15	40.73	0.02	S
			L	40.69	42.09	>0.1	NS

Table 3 (continued)

Sharma MK and Sharma H (2012)[8]	50 Cases 50 Controls	M	R	42.12	39.17	>0.05	NS
			L	39.92	40.93	>0.05	NS
		F	R	45.2	44.37	>0.05	NS
			L	44.52	36.87	<0.001	HS
		M+F	R	43.66	40.00	<0.01	HS
			L	42.22	40.28	>0.05	NS
Present Study (2013)	100 Cases 100 Controls	M	R	44.68	39.86	0.005	HS
			L	41.82	39.38	0.05	NS
		F	R	43.06	41.76	0.21	NS
			L	41.34	41.16	0.84	NS
		M+F	R	43.87	40.81	0.002	HS
			L	41.58	40.27	0.09	NS

(M = Male, F = Female, R = Right, L = Left, SD = Standard Deviation, HS = Highly Significant, NS = Non significant, S = Significant)

The average atd angle (°) was higher in patients diagnosed with diabetes, in the right hand (43.87 °) compared with the control group (40.81 °), the P value was 0.002 (<0.01), the result being statistically significant. At the same time, by comparative measurements between diabetic and non-diabetic patients, an average atd left angle of cases (41.58 °) compared to the control group (40.27 °) was observed, the P value being but of 0.09, therefore, statistically insignificant.

In order to reinforce the results obtained and to conclude the important belief of measuring Atd angle in people at risk of developing (Table 3) diabetes, a comparative presentation of the results of several studies was made. Thus, in the present study (2013) it was found that the angle atd increased significantly in the right hand of the male compared to the right hands of the male control group, which was similar to the results of Rajnigandha V *et al.* (2006)[52] At the same time, the angle atd increased significantly in the right hand of all patients (male and female) compared to the right hand of all cases in the control group, a result that was similar to the findings of Rajnigandha V *et al.* (2006), Padmini MP *et al.* (2011) and Sharma MK and Sharma H (2012)[32,53,52].

From the present study, it can be concluded that there is a significant difference in the angle atd between the patients diagnosed with noninsulin dependent diabetes mellitus and the normal persons. Thus, measuring angle atd can be helpful in finding high risk individuals to develop diabetes.

From Sehmi's study, one can realize an overview of the information offered by the measurement of the angle atd[18] A larger angle atd and additional axial triads have been shown to be reliable indicators in the scientific screening of populations prone to diabetes. Rajnigandha *et al.* (2006)[22] Mittel and Lala (2013)[54] Sharma *et al.* (2013)[26]; Nayak *et al.* (2015)[37] showed an increase in angle atd in both sexes in diabetics while Mandascue *et al.* (2000)[23], Bala *et al.* (2015)[28], Srivastava and Rajasekhar (2014)[52] have shown that decreasing the angle atd would be specific for diabetics. Mandasescu *et al.* (2000)[23] showed that the atd angle of the right hand was significantly lower in male diabetics. Padmini *et al.* (2011)[32] showed an increase in angle atd only in male diabetics. Verbov *et al.* (1973)[36] showed a decrease in the number of a-b in female patients with type 1 diabetes. Similar findings were reported by Zieglar *et al.* (1993).[55]

b. Index of the main lines

The main palmar lines are A, B, C, D, their direction orienting us on the course of the palm ridges. In the general population the grouping of the three hand radians (D, C, B), according to the Wilder formulas, indicates the most frequent ones for the formulas 11-9-7 and to a lesser extent for the formulas 9-7-5, 7-5 -5 and other formulas, calculated by following the direction of the hand line and its end point. In the present research, the calculation of these formulas has led to extremely valuable results. In the sample of diabetic patients, the decreasing order of the frequencies of the Wilder formulas is the same as in the general population, with the difference that for diabetic patients the proportion of formula 11-9-7 is statistically significantly higher than in the control group (Figs. 6 and 7).

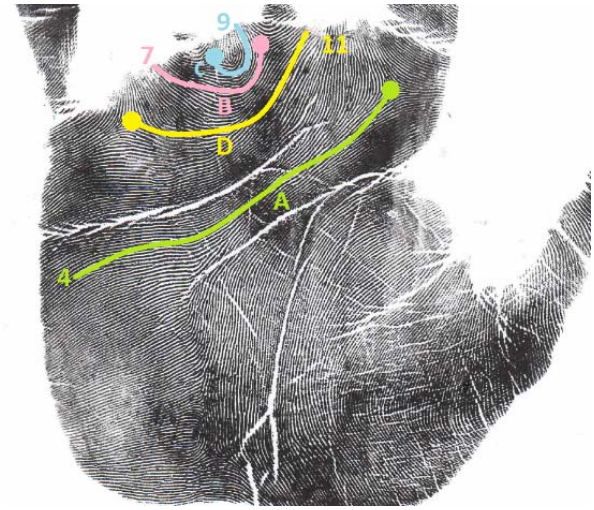

Figure 6. Example of the calculation of the index of the main lines, personal material.

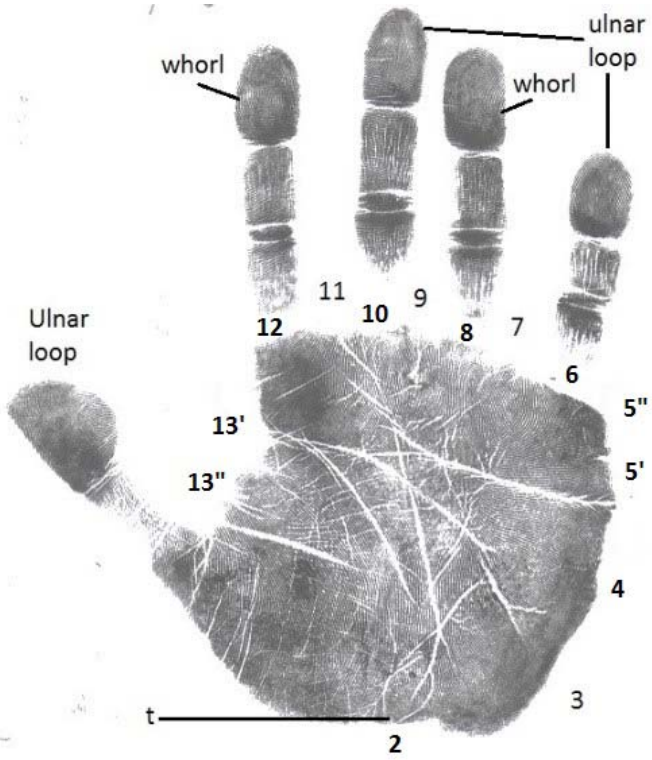

Figure 7. Zonal numerical value, personal material.

CONCLUSIONS

The dermatoglyphic investigation is absolutely cost-effective and does not require hospitalization and can help predict the phenotype of possible future diseases. Several studies conducted on different populations have identified a significant correlation between different patterns of fingerprinting and diabetes, however, the type identified varies from one geographical region to another, and this may be due to racial dermatoglyphic differences, which differ from one population to another. However, after a competent analysis,the results of the different authors seems to agree at a certain level. Possible reasons why not all study results correlate with each other could be, concludes Sehmi, small sample size, incomplete diagnoses, inadequacy of control group, statistical errors and lack of openness of subjects. Although the study of dermatoglyphs does not yet play a role in clinical diagnosis, it may serve as a way to select individuals from a larger population for further investigation, to subsequently confirm or exclude diabetes.

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