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Research Article

Dermatoglyphics in Type 2 Diabetes with Implications on Gene Linkage or Early Developmental Noise: Past Perspectives, Current Trends, & Future Prospects

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Abstract: Clinical Dermatoglyphics is an emerging field of active research with profoung implications, with analysis techniques following descriptive case-control studies. Such studies assess peculiar & significant manifestations among affected individuals relative to healthy controls, attributing these outcomes to gene linkage or developmental instability during prenatal development. This paper critically reviews studies done over a period of 42 years (1972-2014) that have followed such analysis techniques in T2DM, highlighting on strengths & weaknesses. Low sample sizes, negligence of the distinct nature of types & subtypes of DM, negligence of the occurrence of common concurrent disorders having their own impacts on Dermatoglyphics, and a general paucity of studies addressing the relationship between developmental noise measures (Fluctuating Asymmetry) & T2DM are observable limitations that could be attributable to the contradictory findings among the published papers, that need be addressed by future researchers. All in all, inferable positive prdictive values indicative of a predisposition to T2DM have been sumarized, emphasis on the need for further studies from varied populations with larger sample sizes has been proposed inorder to come to conclusive results.
Keywords: Dermatoglyphics, Type 2 Diabetes, Fluctuating Asymmetry, Genetic Linkage.

INTRODUCTION

Diabetes mellitus is a chronic degenerative disease characterized by insufficient insulin secretion or a decreased sensitivity to insulin, and falling into two broad categories referred to as Type 1 Diabetes Mellitus (T1DM) & Type 2 Diabetes Mellitus (T2DM). T2DM is the type that is more common and with a significant increase in prevalence globally. It is a heterogeneous multi-factorial metabolic disorder, with 4 variants recognized thus far, including the typical T2DM (polygenic multi-factorial T2DM), maturity-onset diabetes of youth (MODY), latent adult-onset autoimmune diabetes (LADA), and monogenic or secondary to rare genetic disorders [1].

The typical polygenic multi-factorial T2DM form account for the lion's share (70-85%) of diabetes cases clinically diagnosed worldwide, and is to date ascertained to be significantly associated with about 47 gene loci dispersed among the autosomal & X chromosomes as per genome wide association studies [2, 3].

MODY is a form of T2DM characterized by hyperglycemia, ages of onset & diagnosis below 25, and non-insulin-dependence for 5 or more years following diagnosis. Genetically speaking, it is a monogenic form inherited as an autosomal dominant trait, with about 12 gene loci being found to be significantly associated [1-3]. On the other hand, LADA is a slow progressive form of adult-onset autoimmune diabetes, which is initially non-insulin-dependent during diagnosis [4]. It is complex, and manifests features that lie in between Types 1 & 2 DM [5]. Finally, T2DM in monogenic form secondary to rare genetic disorders has also been identified, occurring concurrently with developmental syndromes such as Wolfram syndrome & growth retardation, accounting for a small fraction (5-10%) of T2DM cases [1-5]

CLINICAL DERMATOGLYPHICS: AN OVERVIEW

Dermatoglyphics develop within the 1st trimester of pregnancy, fully formed at around the 18th week of gestation. They have been shown to exhibit complex inheritance patterns, characterized by polygenes with multi-factorial mechanisms under play [6]. Early reports proposed a possible mode of inheritance of digital patterns by deducing that there are most likely 7 (or more) independent or epistatic genes involved [7]. More recently, linkage analysis in

univariate and multivariate genome scans for digital ridge counts [8] have shown that around 20 loci dispersed among 12 chromosomes returned significant linkages.

Clinical Dermatoglyphics argues on their possible application as preventive counselling techniques and diagnostic aids for a large number of chronic disorders, with such studies categorizable into 2 trends of analysis techniques, the most prevalent one being the direct comparison of Dermatoglyphic variables among affected/predisposed subjects relative to healthy controls, with an initially entailed hypothesis that recognizes the polygene nature of both the Dermatoglyphic traits as well as the multiple susceptibility or resistance conferring gene loci for the disorders, thus entertaining the likelihood of these two gene sets being linked or proximal to each other within the genome.

A second school of thought among more recent researchers further emphasizes on the possible underlying factors for such differences, arguing that such deviations reflect prenatal developmental noise, causing random deviations from the expected bilateral symmetry. Such researchers quantify the degrees to which development instability has occurred by a popular measure referred to as fluctuating asymmetry (FA) [9].

Fluctuating Asymmetry, a parameter used to quantify effects of developmental noise on the wellbeing of individuals, refers to random deviations on both sides of the body having equal averages on both sides of the body for a given population [9-11]. Stressors during prenatal development have been shown to induce FA, including extreme temperatures, environmental pollution, predation risk, population density, and inbreeding. Dermatoglyphics pose the possibility of playing a role as ideal markers in detection of defects due to intra-uterine irregularities in the early weeks of pregnancy [10-12]. To this end, FA has been used to assess various disorders such as: myopia [13], inborn blindness [14]; psychological, psychiatric, and behavioural traits such as intelligence/learning disability [15, 16], alcoholism [17, 18], bipolar mood disorders, and depression & anxiety syndromes [19].

DERMATOGLYPHICS IN T2DM

This paper tries to summarize the major findings of studies relating Dermatoglyphic marker deviations in T2DM, by attaining & critically reviewing all available published materials during the past 42 years (1972-2014) that expounded the relationship between Dermatoglyphics & Diabetes, specifically focusing on those done on T2DM cases. The main search protocol used employed key words such as ["Dermatoglyphics" & "Diabetes"], ["Fingerprint" & "Diabetes"], ["Palm print" & "Diabetes"], & ["Fluctuating Asymmetry" & "Diabetes"] on the web & NCBI/NIH databases. The results yielded were checked for article availability as whole or abstract, while those which were not available were recorded and further browsed for in archives from the website of the journal they were initially published in.

A total of 44 article titles were obtained, of which 25 were available as full text articles while 7 were available as abstracts. The remaining 12 were not available as a whole, mostly since the original articles were published in languages other than English. A thorough evaluation of these studies is summarized herein. A summary of these findings is given in Table 1 [20-63].

Overall, several limitations have been identified, the foremost related to the noticeably low sample size in the cases and/or controls for the majority of these studies, with age & sex matched standard case-control studies following predefined calculated sample sizes being limited. Secondly, some studies have not distinguished between the types of DM, with a few studies having included both types I & 2 DM in their case groups, despite the fact that their etiologic features & underlying genetic mechanisms being distinct. Thirdly, due consideration to the age of onset of DM has not been a focus for most studies, and this might have important implications since variants of the T2DM itself exist, as discussed in the previous section, that differ, among other features, in their age of onset. The forth drawback observed in the majority of the studies relates to their negligence of the possibility of the occurrence in the cases of other commonly occurring concurrent disorders such as HT & CHD, each of which have their own effects on Dermatoglyphics. Finally, only one study [27] has emphasized on the importance of prenatal developmental disturbances (measured by fluctuating asymmetry) in comparisons of cases & controls.

DERMATOGLYPHICS IN T2DM: CASE-CONTROL STUDIES

The earliest observations of peculiar Dermatoglyphics in individuals manifesting DM are attributable to studies done in the 1970's [37, 38, 49, 50, 54, 56-60]. Currently, there exists a hand full of studies carried out expounding Dermatoglyphic manifestations in T2DM, the authors of which have found from one to various significant Dermatoglyphic parameters indicative of predisposition. However, distinctions among the parameters of significance vary from one report to another, and even more strikingly, some findings are contradictory to those forwarded by other counterparts, even for those done from the same subcontinent.

Table 1: Studies assessing the relationship of DM & Dermatoglyphics (Both T1DM & T2DM forms, also articles which are not available or available as abstracts only)

Author	DM Type	Sample Size					Author	DM Type	Sample Size				
		Total	Case		Ctrl				Total	Case		Ctrl	
			M	F	M	F				M	F	M	F
[20]	II	101	28	21	29	23	[42]	II	204	75	-	60	-
[21]	II	254	63	49	65	77	[43]	II	819	109		710	
[22]	I + II	400	100	100	100	100	[44]	I	60	30		30	
[23]	II	100	25	25	42	8	[45]	II	25	-		-	
[24]	II	200	50	50	50	50	[46]	I + II	380	60	130	60	130
[25]	II	150	51	24	47	28	[47]	II	78	-		-	
[26]	II	200	50	50	50	50	[48]	II	700	240	110	240	110
[27]	II	270	75	75	60	60	[49]	N/A	N/A	N/A	N/A	N/A	N/A
[28]	II	200	50	50	50	50	[50]	N/A	N/A	N/A	N/A	N/A	N/A
[29]	II	148	37	37	37	37	[51]	II	N/A	N/A	N/A	N/A	N/A
[30]	II	200	40	60	63	37	[52]	I	395	88	108	100	99
[31]	II	200	50	50	50	50	[53]	I	558	158		400	
[32]	II	300	75	75	75	75	[54]	N/A	N/A	N/A	N/A	N/A	N/A
[33]	II	200	50	50	50	50	[55]	I	N/A	N/A	N/A	N/A	N/A
[34]	II	250	65	35	75	75	[56]	N/A	N/A	N/A	N/A	N/A	N/A
[35]	II	300	N/A	N/A	N/A	N/A	[57]	N/A	N/A	N/A	N/A	N/A	N/A
[36]	II	270	75	75	60	60	[58]	N/A	N/A	N/A	N/A	N/A	N/A
[37]	I + II	470	N/A	N/A	N/A	N/A	[59]	N/A	N/A	N/A	N/A	N/A	N/A
[38]	N/A	943	108	65	536	234	[60]	N/A	N/A	N/A	N/A	N/A	N/A
[39]	II	201	51	50	50	50	[61]	N/A	N/A	N/A	N/A	N/A	N/A
[40]	II	277	33	68	50	76	[62]	N/A	N/A	N/A	N/A	N/A	N/A
[41]	I	210	112		98		[63]	N/A	N/A	N/A	N/A	N/A	N/A

(N/A- not available)

FINGERPRINT PATTERNS

Several contradicting findings are observable for the distributions of fingerprint pattern among T2DM cases & controls in the various studies (Table 2). Five authors have reported a significant decrease in frequency of Ulnar Loops with a proportional increase in the Whorls [33, 24, 29, 23, 48]. Related to this, except for two of these authors [23, 29], an entailed decrease in the arches has also been noted.

Table 2: Fingerprint pattern distribution trends in T2DM cases relative to the controls among the various authors that have analyzed this variable

Author	Sex	Side	Fingerprint Patterns				Author	Sex	Side	Fingerprint Patterns			
			L_U	L_R	A	W				L_U	L_R	A	W
[39]	M	R	↑	↓	↑	↓	[24]	M+F	R+L	* ↓	=	↓	* ↑
		L	↑	↑	↑	↓	[25]	M	R+L	↓	=	↑	↑
		R+L	↑	↓	↑	↓		F	R+L	↓	=	↓	↑
	F	R	↑	↓	↑	* ↓	[48]	M	R	* ↓	↓	* ↓	* ↑
		L	↑	↑	* ↑	* ↓			L	* ↓	↓	* ↓	* ↑
		R+L	↑	=	* ↑	* ↓		F	R	* ↓	↓	↓	* ↑
[33]	M	R	* ↓	↑	* ↓	* ↑			L	* ↓	↓	↓	* ↑
		L	* ↓	↓	↓	* ↑	[34]	M	R+L	*↑		* ↑	* ↓
	F	R	* ↓	↑	↓	* ↑		F	R+L	↑		↑	↓
		L	* ↓	↓	* ↓	* ↑	[23]	M+F	R+L	*↓		↑	* ↑
[20]	M	R+L	↓	↓	↓	↑	[29]	M	R+L	↓	=	↑	↑
	F	R+L	↑	↓	=	↓		F	R+L	↓	↑	↑	↑
[31]	M	R	* ↓	* ↓	* ↓	* ↑	[40]	M	R	↓		↑	↓
		L	* ↓	* ↓	* ↓	* ↑			L	↓		↑	↓
		R+L	* ↓	* ↓	* ↓	* ↑		F	R	↓		↑	↓
	F	R	↓	↓	↓	↑			L	↓		↑	↓
		L	↓	↓	↓	↑		M+F	R	↓		↑	↓
		R+L	↓	↓	↓	↑			L	↓		↑	↓

(L_U- Ulnar Loop; L_R-Radial Loop; A-Arch; W-Whorl; M-Male; F-Female; R-Right Hand; L- Left Hand; ↑-Increase;↓-Decrease; *-Statistically Significant; =- approximately equal or differences very minimal

This characteristic decrease in Ulnar loops of T2DM patients is a notable finding shared by the majority of the literature [23-25, 29, 31, 33, 40, 48], with only 3 authors reporting an increased ulnar loop frequency in one or both sides of either of the sexes [20, 34, 39], of which only 1 stating significance [34]. Similarly, the characteristic increase in the whorl pattern in T2DM patients was a common finding for the majority of the studies [33, 24, 48, 29, 23, 31]. In contrast, lower whorl frequencies were also noted in T2DM cases for both sides in both sexes by 3 authors [39, 34, 25], for the males only by one author [40], and in only the females by another [20]. However, statistical significance was reported by only two of these authors: the first in the overall cases [34], and the second for the females only [39].

Pattern frequency variation among the different studies for the radial loops & the Arch patterns showed higher fluctuations among the different authors. Considering the radial loop pattern, the overall frequency in the total samples (cases plus controls) for most of these studies was generally less than 10%. Further, several of the studies have failed to differentiate between the radial & ulnar variants the loops. Owing to these factors, no conclusive deductions can be made confidently regarding the radial loop patterns.

As to the arch frequencies, 4 authors [34, 23, 39, 29] reported increased occurrences overall, while a couple have reported increased occurrences in males with concurrently reduced frequencies in the females [25, 40]. Significance wise, two authors for the overall increase of arches in T2DM cases [34, 29], and one for that in females, are notable [39]. The other authors [31, 48, 24, 20, 33] reported an overall decrease in arch patterns among T2DM cases, with the results of one [33] being significant for the right side of males & the left side of females, and two others for the males only [48, 31].

PALMAR ANGLES

Regarding the ATD angle (Table 3), the various findings can be grouped into two. The first & majority group consists of findings reporting an increased ATD in diabetic subjects compared to healthy individuals, while the second group comprises those which found a decrease in the ATD angle of cases relative to the controls, on one or both sides in males and/or females. Significantly increased mean ATD angles in both males & females on both right & left sides have been reported by two authors [21, 26]. Other authors have reported increased ATDs in one or both sides in either of the sexes. Five authors [20, 22, 23, 28, 31] have reported significantly increased ATDs, respectively on the left side of males, on the right side of overall diabetics, on the left side of females and the right side of overall diabetics, on both sides of males & on the right side of overall diabetics, and, in males combining both sides and in females on the left side and combining both sides. Most of these authors also reported increased values on the other sides of the males or females, but such findings were not as such statistically significant.

Table 3: Palmar angles (ATD, TDA, TAD) distribution trends in T2DM cases relative to the controls among the various authors that have analyzed this variable

Author	Sex	Side	Palmar Angles		
			ATD	TDA	TAD
[31]	M	R	=	* ↓	↑
		L	=	* ↓	↑
		R+L	* ↑	* ↓	↑
	F	R	=	* ↓	↑
		L	* ↑	* ↓	↑
		R+L	* ↑	* ↓	↑
[20]	M	R	↑	-	-
		L	=		
	F	R	↓		
		L	↓		
[26]	M	R	* ↓	* ↓	=
		L	* ↓	* ↓	↓
	F	R	* ↓	* ↓	* ↓
		L	* ↓	* ↓	* ↓
	M+F	R	* ↑	* ↓	↓
		L	* ↑	* ↓	↓
[21]	M	R	* ↑		
		L	* ↑		
	F	R	* ↑		
		L	* ↑		
	M+F	R+L	* ↑		
[25]	M	R	↑		
		L	↑		
	F	R	↓		
		L	↓		
[23]	M	R	↑	↓	↓
		L	↓	↑	↓
	F	R	↑	↓	↓
		L	↑	↓	↓
	M+F	R+L	↑	↓	↓
[28]	M	R	* ↑		
		L	* ↑		
	F	R	↑		
		L	↑		
	M+F	R	* ↑		
		L	↑		
[29]	M+F	R+L	↑		

(M-Male; F-Female; R-Right Hand; L- Left Hand; ↑-Increase;↓-Decrease; *-Statistically Significant; =-approximately equal or differences very minimal)

In contrast, decreased ATDs have been reported on one or both sides in males or females [20, 22, 23-25, 27, 30], but these findings turned out to be significant only in two cases: on both sides of the

females in Gabriel & Babajide's study [20], and on the left side of females by Padmini's team [22].

Other angles studied by a few of the researchers include the TAD & TDA angles. Ojha & Gupta [31] have reported significantly decreased TDA angles in both males & female cases on both sides, with concurrently increased TAD angles on both sides of both sexes, though significance was noted only for the right side of females. This result is in part concordant with those reported by Sharma & Sharma [23], in that the TDA angles in this study were also decreased on both sides in both sexes, being significant for the left hands of the females. In contrast, the TDA angles were reduced on both hands of both sexes in the cases of the latter study, being significant for the right hands of the females and the overall diabetic patients.

DIGITAL & PALMAR RIDGE COUNTS

Table 4: Digital (TFRC, AFRC) & Palmar ridge count (a-b RC) distribution trends in T2DM cases relative to the controls among the various authors that have analyzed this variable

Author	Sex	Side	Various Ridge Counts		
			TFRC	AFRC	a-b RC
[39]	M	R+L	↓	↓	-
	F	R+L	* ↓	* ↓	
[31]	M	R	* ↑	↑	
		L	* ↑	↑	
		R+L	* ↑	↑	
	F	R	* ↑	* ↑	
		L	* ↑	↑	
		R+L	* ↑	* ↑	
[24]	M+F	R+L			* ↓
[25]	M	R+L			
		R	↑		↑
		L	↑		↑
	F	R	↑		↓
		L	↑		↓
		R+L			
[27]	M	R	↓		=
		L	↓		=
	F	R	↓		=
		L	↓		=
[23]	M	R			↓
		L			↑
		R+L	↑	↑	
	F	R			↑
		L			↑
		R+L	↑	↑	

(TFRC-Total Finger Ridge Count; AFRC-Absolute Finger Ridge Count; a-b RC-a-b Ridge Count; M-Male; F-Female; R-Right Hand; L- Left Hand; ↑-Increase;↓-Decrease; *-Statistically Significant; =- approximately equal or differences very minimal)

The Digital & Palmar RC findings show lesser variations among the various authors as compared to the other parameters (Table 4). Considering the TFRC, the majority of the authors that have quantified this variable have reported an increased mean value in diabetic cases compared to controls. Six authors have reported an increased TFRC in both the males & females [51, 25, 23, 22, 31, 37], with four of these results being significant [51, 22, 31, 37]. In contrast, two authors have reported decreased TFRCs [39, 27], but only one author found significance, which was further limited to the female cases only [39].

Similarly, for the AFRC, out of four authors that have analysed this parameter, three have reported increased means in the diabetic group compared to the controls [23, 22, 31], while only one has reported decreased AFRC values that was significant only for the females [39].

As to the a-b RC, increased & decreased mean values for the overall diabetic cases have been respectively reported by one author each [32, 24]. One author has found increased means for the males with simultaneously lower values for the females [25], while another author has reported an increased mean for the left side of males and both sides of the female cases, with a decreased value for the right side of the male patients [23].

OTHER DERMATOGLYPHIC PARAMETERS

Other parameters compared between T2DM cases & controls include the axial triradii variations, palmar patterns, C-line variations, and the presence of special palmar patterns or distortions. Regarding the axial triradii variations and their distal deviations, it can be deduced that this is a characteristic which primarily correlates with the increased ATD angles in the T2DM cases. Distal deviation of the t triradius or the presence of additional distally located triradii t' & t'' on the palms is a characteristic feature manifested in T2DM cases for most of the studies that have evaluated this parameter.

Three studies [21, 31, 23] have reported a significant increase in the occurrence of the distally deviated t' & t'' axial trirad2 on the palms of both hands in both sexes, with a concurrent decrease in the frequency of the normal t axial triradius, while one study reported an increase in the t & t' variants with a simultaneous decrease in the most distal deviated variant, the t'' type, but the results turned out to be insignificant [32]. Finally, Tarca [46] has reported that the absence from the palm of triradius t was a typical feature of DM cases and more significantly in females or the left hands of the males.

With reference to the C-line patterns, Pathan & Hashmi [24] found that the absent C line was a typical manifestation in T2DM cases, being absent in about

50% of the hands of diabetics compared to only about 5% of the hands of non-diabetics. Simultaneously, the C proximal, radial, & ulnar variants were decreased in the diabetics, although the decrease in the C Ulnar variant was not statistically significant. Sharma & Sharma [23] reported that the proximal C-line pattern was absent in the diabetics, while it was manifested on the left hands in the healthy controls. Similar to the findings of Platilova's team [35], they have found that T2DM cases manifested decreased Absent, Proximal & Ulnar variants.

Dermatoglyphic FA & T2DM

Although explorative studies are ubiquitous for many of the emerging chronic degenerative disorders that are recording a high rise in prevalence, those relating DM and developmental homeostasis via measurement of FA are relatively few in number. Initially, animal studies had pointed out a significant rise in FA in offspring whose mothers were suffering from diabetes as compared to those derived from healthy ones [64]. PNMS has been shown to be significantly correlated with the development of DM or factors involved in its development [64].

Considering human studies, it has been recently shown that foetuses of mothers that have faced hunger during their prenatal development have a higher risk of developing chronic diseases such as DM later during their lives as adults [65, 66]. Similarly, a group of researchers measured glucose tolerances among 32 adolescents whose mothers were exposed to the catastrophic 1998 Quebec ice storm, and found that the severity of stress faced by the mothers was positively associated with insulin secretion & BMI of the adolescents, with increased insulin secretions & BMIs (obesity) being signified, both of which are risk factors for the development of DM. Such increases in insulin levels are in fact known to be an early feature of insulin resistance that leads to DM [67]. These and related findings point out the importance of PN developmental homeostasis in the assessment of predisposition to DM, with Dermatoglyphic variables being able to play a pivotal role in quantifying the degree to which such stresses have affected the fetus [10, 67].

Kahn's team [42] from Atlanta tested associations of the waist-to-thigh ratio with 20 ridge-count differences and found that an increased the asymmetry on the 4^{th} & 5^{th} digits (dR45) leads to an upper-body tissue distribution originating before the midpoint of pregnancy, with increased BMI values that were characteristic features of a subsample taken that consisted of adult diabetic males.

A group of researchers from India [27] analyzed quantitative digital & palmar variables (RCs) among 150 T2DM cases and compared them to 120 controls, and reported that an overall higher value of FA was a distinguishing feature of Diabetic patients, and more specifically, significantly higher FA values for the RC of the 5^{th} finger & the palmar DAT angle in the diabetic males and for the RC of the 2^{nd} finger in the diabetic females.

Another group of researchers [43], forwarding the high possibility of the fetal programming of DM to arise during early gestation and acknowledging the fact that genetic influence on the RCs of the 1^{st} & 5^{th} digits being minimal, as established from previous studies [8], hypothesized that the mean ridge count difference between these fingers, which they termed "Md15," reflects environmental conditions during early gestation that could be employed to predict adult-onset diabetes. Having tested this in a sample of adults that were born during the 1943-47 Dutch famine compared to unexposed controls, they concluded that DM with age of onset/diagnosis greater than or equal to 50 was associated with this Dermatoglyphic parameter, and highlighted on the importance of Dermatoglyphic asymmetry variables in studying the prenatal origins & prediction of T2DM.

All of the above reviewed studies have showed that consideration of the development of chronic degenerative disorders such as T2DM as to being correlated with developmental instability caused by both environmental and genetic stresses a crucial point if one wants to come to conclusive deductions & inferences as to the predisposing factors & their positive predictive indices for such disorders.

CONCLUSION

As accentuated by a recent report [68], a thorough review of the principles & practices of Dermatoglyphic research in certain disorders is an area of research that is hope giving & with profound prospects for understanding the underlying genetic mechanisms in play both during the formation of Dermatoglyphic traits as well as the resistance/susceptibility trends of individuals or groups sharing common variants at the gene level. The studies conducted so far however have several limitations that have been identified. Low sample sizes, study designs not in accordance with the standard case-control sampling and analysis procedures, negligence of the distinct nature of the types of DM & their subtypes, a negligence of the possibility of occurrence of other common concurrent disorders such as HT & CHD in the cases, and less emphasis on the importance of prenatal developmental disturbances in the development of such disorders & entailed Dermatoglyphic deviations, can be taken as key issues that need be addressed in such researches, but are in general not a common feature for most of the studies done so far, possibly explaining the numerous contradictory findings among them.

All in all, the most frequently shared findings that are indicative of a predisposition to T2DM among

the various studies include: a decrease in Ulnar loops on the digits entailing a simultaneous increase in the whorls, increased mean TFRC & AFRC values, increased ATD angles, and distally deviated palmar Axial Trirad. However, further studies from varied races & larger sample sizes are required to come to definitive conclusive results.

Recommendations

As can be concluded from the discussions above, a vast and thorough research expounding the genetic background of the various dermatoglyphic traits is invaluable to generate a framework for understanding the underlying mechanism by which they are related both to individual and/or population wise variations, as well as to the various disorders they have been found to be related with. Such information, once generated, can establish a link between these genes & ascertained resistance/susceptibility genes for the disorders, in particular T2DM. Secondly, any study which is to be conducted in the future regarding dermatoglyphic markers in T2DM should adhere to the standard case control study designs with ample sample sizes. Thirdly, the researches should give due emphasis to the importance of differentiating between the DM types & subtypes, as well as manifestations of concurrent disorders such as HT & CHD among cases, which might have an impact on dermatoglyphic manifestations per se.

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