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Study of Gender Differences in Palmar Dermatoglyphics among Healthy Adults

Deepa G.*, Shrikrishna B.H.**

Abstract

Background & Objectives: Fingerprint (dermatoglyphic) evidence is undoubtedly the most reliable and acceptable evidence till date in the court of law. Due to the immense potential of fingerprint as an effective method of identification an attempt has been made in the present work to analyse their correlation with gender of an individual. This study was done to determine significant differences in palmar dermatoglyphic parameters between males and females. *Methods:* Residents of Nijalingappa colony of Raichur in Karnataka were the source of this study. 50 adult healthy males in the age group of 20 to 40 years and 50 adult healthy females of same age group were the subjects for this study. Sample collection was done by doing home visits and collecting palmar impression. Fingerprint pattern of all of them was recorded using duplicating ink. The prints were then subjected to dermatoglyphic analysis. *Results:* The Total Finger Ridge Count (TFRC) was significantly more in males compared to females. Females had significantly higher a-b ridge counts than males. There were no significant differences in the other parameters between males and females. *Interpretation & Conclusion:* The gender differences in the dermatoglyphic patterns of palms are established by this study. This information is useful in forensic studies in identifying gender of a person.

Keywords: Dermatoglyphics; Hand; Fingers; Male; Female; Forensic Medicine.

Introduction

Gender and Age information is important to provide investigative leads for finding unknown persons. Existing methods for gender classification have limited use for crime scene investigation because they depend on the availability of teeth, bones, or other identifiable body parts having physical features that allow gender and age estimation by conventional methods. Various methodologies has been used to identify the gender using different biometrics traits such as face, gait, iris, hand shape, speech and fingerprint. The science of fingerprint has been used generally for the identification or verification of person and for official documentation. Two persons having identical fingerprint is about one in 64 thousand millions. A reliable personal identification is critical in the subject of forensic medicine as is faced with many situations like civil, criminal, commercial and latest in financial transaction frauds, where the question of identification becomes a matter of paramount importance [1].

Dermatoglyphics are also used in the branch of forensic medicine for individual identification. It is a valuable research tool in the field of physical anthropology, human genetics and medicine. Recently, a few researches have been carried out on this aspect of fingerprint [2-6]. All of these papers have reported higher epidermal ridge density in females as compared to males. The present study has been carried out to study such correlation between gender and dermatoglyphics.

Objective

This study was done to determine significant differences in palmar dermatoglyphic parameters between males and females.

Author's Affiliation: *Assistant Professor, Department of Anatomy, Navodaya Medical College, Raichur (Karnataka)-584103. **Professor, Department of ENT, Navodaya Medical College, Raichur (Karnataka)-584103.

Corresponding Author: Deepa G., Assistant Professor, Department of Anatomy, Navodaya Medical College, Raichur (Karnataka)-584103.
E-mail: drdeepagadwal@gmail.com

Materials and Methods

Source of Data

Residents of Nijalingappa colony of Raichur in Karnataka were the source of this study. 50 adult healthy males in the age group of 20 to 40 years and 50 adult healthy females of same age group were the subjects for this study. Sample collection was done by doing home visits and collecting palmar impression.

Sample Size

For the present study 100 subjects (50 males and 50 females) were taken.

Inclusion Criteria

1. Adults in the age group of 20 to 40 years.
2. No past history of any chronic illnesses like Diabetes Mellitus, Hypertension etc.

Exclusion Criteria

1. History of any chronic illness.
2. Deformity or injury to the hand.
3. Those having worn finger-prints, extra, webbed or bandaged fingers.
4. Chromosomal abnormalities like Klinefelter's syndrome, Turner's syndrome etc.

Sampling Procedure

Patients were asked to wash both their hands with soap and water, so as to remove any oil or dirt. The duplicating ink is smeared on both hands uniformly over the palm and digits by the roller taking care that hollow of the palm and the flexor creases of the wrist were uniformly inked. The hand of the patient was then placed on the bond paper from proximal to distal end. The palm was gently pressed between inter-metacarpal grooves at the root of fingers and on the dorsal side corresponding to thenar and hypothenar regions. The procedure was repeated with the other hand on a separate paper (Figures 1 to 3).

The prints were then subjected to dermatoglyphic analysis with the help of magnifying hand lens and protractor and ridge counting was done with the help of a sharp needle. The details were noted.

The quantitative analysis was done with parameters that included Total Finger Ridge Count (TFRC), Absolute Finger Ridge Count (AFRC), ridge count of individual fingers, a-b ridge count, angles atd, dat, adt and main line index. The qualitative tests included finger print patterns, palmar patterns, C-main line type, main line terminations and palmar flexion creases. The master chart thus prepared was subjected to statistical analysis.

Data was expressed in mean (SD). Descriptive statistics was used such as mean, SD etc. Comparison between groups, hands and gender was done using z-test for large sample for continuous variable and for categorical variable, contingency coefficient was used. A p-value less than 0.05 considered as significant and 0.01 as highly significant. All the statistical calculations were done by SPSS v16.0. P value is the probability rate at 0.05 level of significance for the corresponding degree of freedom. $P < 0.05$ is significant. $P > 0.05$ is non-significant.

Results

The Total Finger Ridge Count (TFRC) was significantly more in males compared to females, while there was no significant differences in Absolute Ridge Count (AFRC) between males and females (Table 1). When analysis was done among the male subjects only, no significant difference was observed between left and right hand TFRC and AFRC of male subjects (Table 2). When analysis was done among the female subjects only, no significant difference was observed between left and right hand TFRC and AFRC of female subjects (Table 3). In our study, females had significantly higher a-b ridge counts than males while no significance difference was observed between left and right hand a-b ridge counts in both sexes (Table 4). There was also no significant differences in the a-b ridge count and Main Line Index (MLI) between males and females in our study (Table 5). No significant difference was observed in the atd, dat and adt angles of right and left hands of the male group (Table 6). In a similar way, no significant difference was observed in the atd, dat and adt angles of right and left hands of the female group (Table 7). Also, no significant difference was observed in the atd, dat and adt angles when compared between males and females (Table 8). There was no significant difference between left and right hands in all D1, D2, D3, D4 and D5 finger tip ridge count in male subjects (Table 9). Similarly, in females too, there was no significant difference between left and right hands in all D1, D2, D3, D4 and D5 finger tip ridge count (Table 10). Also, in all D1, D2, D3, D4 and D5 finger tip ridge patterns, non-significant associations were observed between male and female groups as all the

obtained contingency coefficient values were found to be non-significant (Table 11). When the C-Main Line Termination type frequency was studied, for both left and right hands, in both male and female group, significant association was not observed (Table 12). When the Main Line Formula type frequency was studied, for both left and right hands, in both male and female group, significant association was not observed (Table 13). When the t-axial triradii position frequency was studied, for both left and right hands, in both male and female group, significant association was not observed (Table 14).

Thus, in our study, the Total Finger Ridge Count (TFRC) was significantly more in males compared to females. Females had significantly higher a-b ridge counts than males. There were no significant differences in the other parameters between males and females.

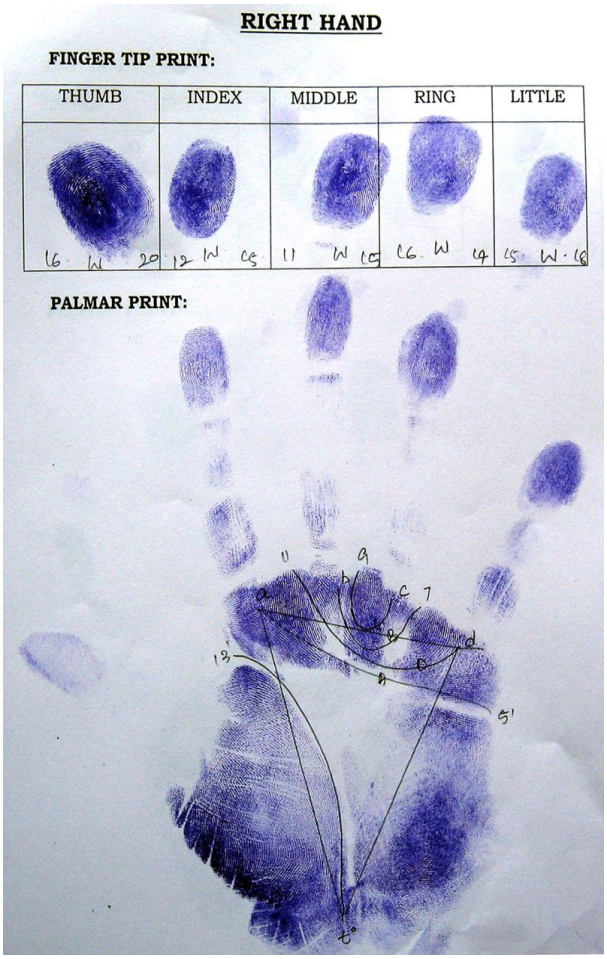

Fig. 1: Palmar print of right hand in an adult male

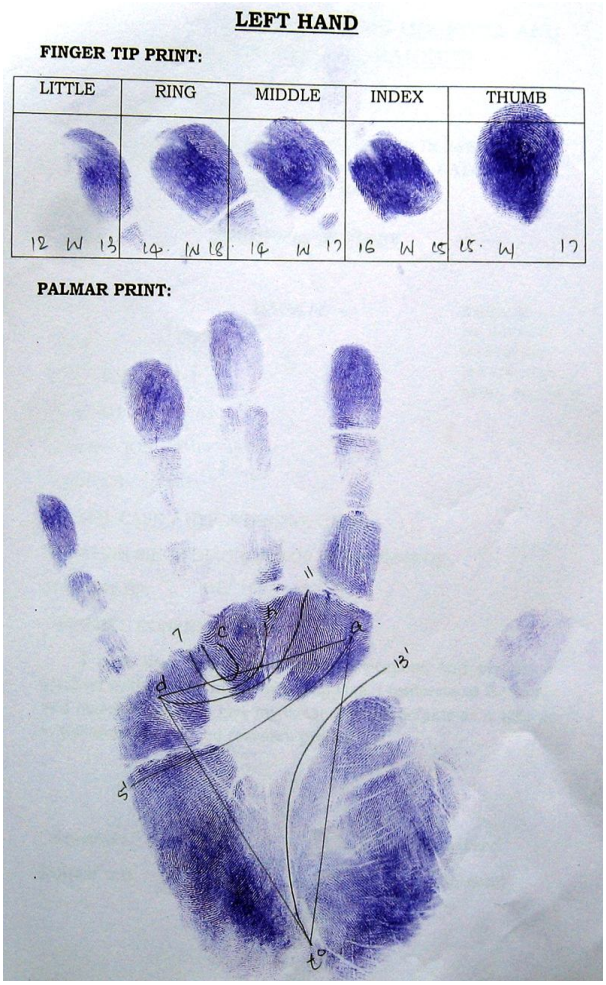

Fig. 2: Palmar print of left hand in an adult female

Table 1: Total and absolute finger ridge counts in 100 subjects (50m, 50f) (hands combined)

Variables	Subjects			Z–value	Significance
	Male Mean (SD)	Female Mean (SD)	Total Mean (SD)		
TFRC	56.26 (18.7)	48.83 (15.5)	52.5 (17.1)	2.16	Significant
AFRC	78.09 (35.7)	69.41 (30.0)	73.8 (32.9)	1.32	Not significant

Table 2: Total and absolute finger ridge counts in 50 male subjects (hands separate)

Variables	Subjects			Z–value	Significance
	Left Mean (SD)	Right Mean (SD)	Total Mean (SD)		
TFRC	56.8 (18.9)	55.7 (18.6)	56.3 (18.8)	0.29	Not Significant
AFRC	77.3 (36.3)	78.9 (35.4)	78.1 (35.9)	0.22	Not Significant

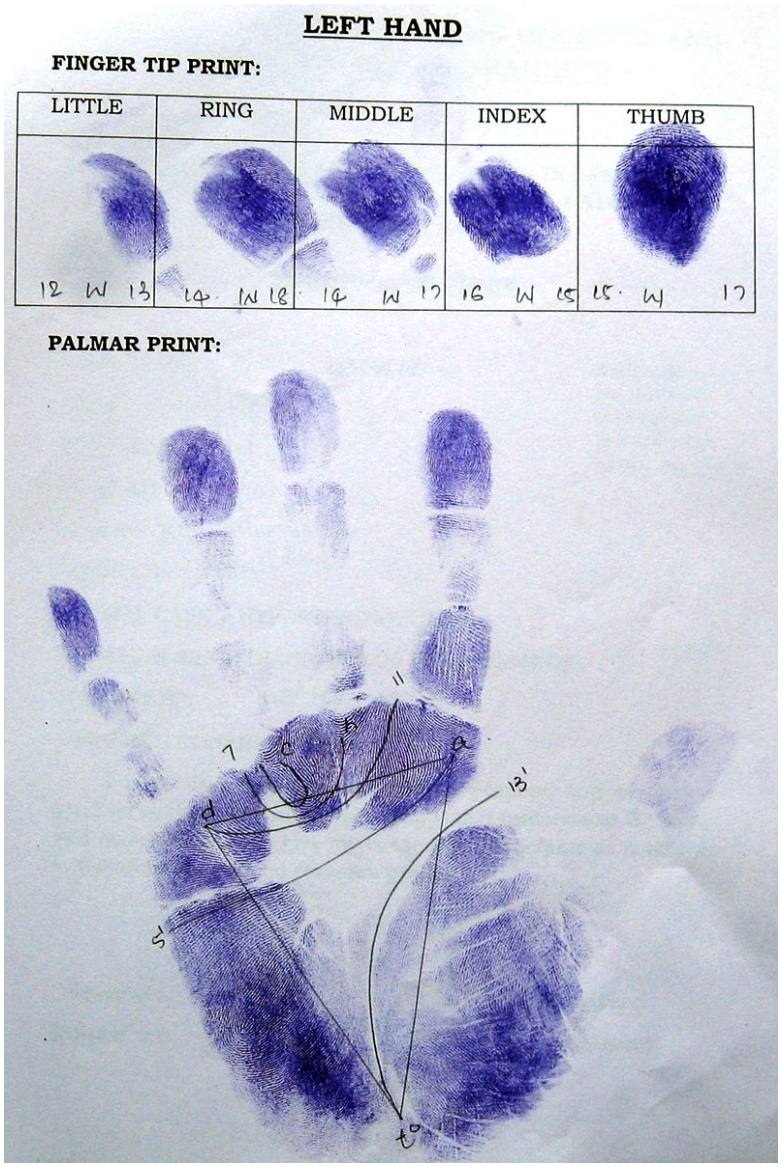

Fig. 3: Proforma for recording the dermatoglyphic parameters

Table 3: Total and absolute finger ridge counts in 50 female subjects (hands separate)

Variables	SUBJECTS			Z–value	Significance
	Left Hand Mean (SD)	Right Hand Mean (SD)	Total Mean (SD)		
TFRC	48.9 (15.7)	48.8 (15.3)	48.9 (15.5)	0.03	Not Significant
AFRC	70.9 (30.6)	67.9 (29.6)	69.4 (30.1)	0.49	Not Significant

Table 4 : A-B ridge counts in 100 subjects (50m, 50f) (hands separate)

Hand	Sex	Mean	SD	Z-value	Significance
Left	Male	28.76	7.0	1.46	Not Significant
	Female	30.42	3.9		
	Total	29.59	5.5		
Right	Male	27.38	6.4	1.47	Not Significant
	Female	28.90	3.5		
	Total	28.14	4.9		
Total	Male	28.07	6.67	2.07	Significant
	Female	29.66	3.77		
	Total	28.87	5.22		

Table 5: A-B ridge count and main line index in 100 subjects (50m, 50f) (hands combined)

Variables	Male Subjects Mean (SD)	Female Subjects Mean (SD)	Total Subjects Mean (SD)	Z-value	Significance
MLI	10 (1.8)	9.4 (1.8)	9.7 (1.8)	1.66	Not Significant
a-b	28.1 (6.7)	29.7 (3.8)	28.9 (5.5)	1.46	Not Significant

Table 6: Angles atd, dat, adt in 50 male subjects (hands separate)

Variables	Left Hand Mean (SD)	Right Hand Mean (SD)	Total Mean (SD)	Z–value	Significance
Atd	40.3 (8.9)	41.2 (6.9)	40.7 (8.0)	0.56	Not Significant
Dat	58.7 (9.4)	58.5 (5.3)	58.6 (7.6)	0.13	Not Significant
Adt	78.7 (12.7)	81.6 (4.2)	80.2 (9.5)	1.53	Not Significant

Table 7: Angles, atd, dat, adt in 50 female subjects (hands separate)

Variables	Left Hand Mean (SD)	Right Hand Mean (SD)	Total Mean (SD)	Z–value	Significance
ATD	40.4 (4.7)	40.2 (4.1)	40.3 (4.4)	0.22	Not Significant
dat	59.4 (5.2)	58.9 (9.9)	59.1 (7.9)	0.31	Not Significant
ADT	80.5 (3.5)	80.1 (7.3)	80.3 (5.7)	0.34	Not Significant

Table 8: angles, atd, dat, adt in 100 subjects (50m, 50f) (hands combined)

Variables	Male Subjects Mean (SD)	Female Subjects Mean (SD)	Total Mean (SD)	Z–Value	Significance
ATD	41.1 (6.9)	40.3 (4.4)	40.7 (5.8)	0.69	Not Significant
DAT	59.2 (4.8)	59.1 (7.9)	59.1 (6.5)	0.07	Not Significant
ADT	81.0 (5.0)	80.3 (5.7)	80.6 (5.4)	0.65	Not Significant

Table 9: Finger tip ridge count in 50 male subjects (hands separate)

Variable	Left Hand Mean (SD)	Right Hand Mean (SD)	Total Mean (SD)	Z–value	Significance
D1	14.9 (8.0)	17.1 (7.8)	16 (7.9)	1.39	Not Significant
D2	14.1 (8.4)	13.1 (7.6)	13.6 (8)	0.62	Not Significant
D3	14.8 (7.5)	13.5 (8.4)	14.2 (7.9)	0.81	Not Significant
D4	17.4 (6.3)	17.3 (7.9)	17.4 (7.1)	0.07	Not Significant
D5	12.3 (5.1)	12.1 (6.0)	12.2 (5.6)	0.18	Not Significant

Table 10: Fingertip ridge counts in 50 female subjects (hands separate)

Variables	Left Hand Mean (SD)	Right Hand Mean (SD)	Total Mean (SD)	Z-value	Significance
D1	15.8 (8.7)	15.3 (8.8)	15.5 (8.7)	0.28	Not Significant
D2	13.1 (8.5)	13.9 (7.8)	13.5 (8.1)	0.49	Not Significant
D3	13.6 (8.1)	12.5 (6.7)	13.0 (7.4)	0.74	Not Significant
D4	16.7 (7.3)	16.6 (7.7)	16.7 (7.5)	0.06	Not Significant
D5	11.3 (6.3)	10.8 (5.9)	11.1 (6.1)	0.41	Not Significant

Table 11: Finger tip pattern frequency in 100 subjects (50m, 50f) (hands separate)

Variables		LEFT		RIGHT	
		Male Subjects	Female subjects	Male subjects	Female subjects
D1	Whorl	19	27	28	21
	Arch	3	4	0	4
	Loop	28	19	22	25
	Contingency coefficient	0.177	P= 0.196		0.22 P=0.07
D2	Whorl	21	25	22	27
	Arch	3	8	4	5
	Loop	26	17	24	18
	Contingency coefficient	0.21	P=0.105	0.12	P=0.47
	Whorl	21	21	19	15

	Arch	2		4	2	2
	Loop	27		25	29	33
	Contingency coefficient	0.08	P=0.69		0.08	P=0.69
D4	Whorl	31		32	30	29
	Arch	0		0	0	1
	Loop	19		18	20	20
	Contingency coefficient	0.02	P=0.84		0.10	P=0.6
		(Calculated only for two rows as 'arch' was nil in both the group)				
D5	Whorl	17		14	18	13
	Arch	0		3	0	1
	Loop	33		33	32	36
	Contingency coefficient	0.17	P=0.19		0.14	P=0.36

Table 12: C-main line termination type frequency in 100 subjects (50m, 50f) (hands separate)

Variables		Male subjects	Female subjects
Left	C-Absent	2	1
	C-Ulnar	19	24
	C-Radial	29	25
	Contingency coefficient	0.10	P=0.55
Right	C-Absent	1	0
	C-Ulnar	17	26
	C-Radial	32	24
	Contingency coefficient	0.20	P=0.13

Table 13: Main line formula type frequency in 100 subjects (50m, 50f) (hands separate)

Variables			Male subjects	Female subjects	
LEFT	11 9 7 5' 13'		16	15	
	9 7 5' 4 13'		2	2	
	7 5'' 5' 4 13'		1	1	
	Others		31	32	
	Contingency coefficient	0.02			P=0.99
RIGHT	11 9 7 5' 13'		16	14	
	9 7 5' 4 13'		0	4	
	7 5'' 5' 4 13'		1	1	
	Others		33	31	
	Contingency coefficient	0.20			P=0.24

Table 14: T-axial triradii position frequency in 100 subjects (50m, 50f) (hands separate)

Variables			Male subjects	Female subjects	
LEFT	T		45	44	
	t^1		5	6	
	$t + t^1$		0	0	
	Contingency coefficient	0.03			P=0.74
		(Calculated only for two rows as 't + t¹' was nil in both the group)			
RIGHT	T		43	48	
	t^1		6	2	
	$t + t^1$		1	0	
	Contingency coefficient	0.18			P=0.19

Discussion

Dermatoglyphics is the scientific study of epidermal ridges and their configurations on palmar region of hand and fingers and plantar region of foot and toes. It is also known as 'Epidermal ridge configurations'[7]. The term dermatoglyphics was coined by Cummins and Midlo in 1926. It was derived from the Greek words-derma (skin) and glyphics (curve). The scientific study of papillary ridges of hands and feet was first begun in 1823 by Evangelista Purkinje –a Czech physiologist and biologist. He was the first who systematically categorized finger print pattern [8].

Development of epidermal ridges is first seen in the form of localized cell proliferation in the basal layer of epidermis around 10th to 11th week of human prenatal development. These cells proliferations form epidermal ridges that project into dermis. The number of primary ridges, as they are termed continues to

increase by the formation of new ridges between existing ridges or from existing ridges on the periphery of the pattern [9]. The epidermal ridges are differentiated in their definitive form during 3rd and 4th month of fetal life, hence they are the significant indicators of conditions existing several months prior to birth of individual. The original ridge characteristics are not disturbed unless the skin is not damaged up to a depth of about one millimeter [7]. According to Penrose , seven genes are thought to be involved in the fingerprint formation. In polygenic inheritance, the genes that confer this follow Mendel's laws, but, together, they do not produce a single-gene phenotypic ratio. Instead, they all contribute to the phenotype without being dominant or recessive to each other.The epidermal ridge configuration and their component ridges enlarge with growth, but their essential characteristics remain the same throughout life [10].

In 1892 Sir Francis Galton demonstrated that epidermal ridge configuration did not change throughout postnatal life. The fact that ridge configurations are not affected by environment or by age, has been an important framework in genetic studies. While the genetic basis of dermatoglyphic traits has been well established, current research suggests that the genetic component of dermatoglyphic traits operates indirectly on ridge configuration through ontogenetic factors, pad topography, growth rates and stress on epidermis, that influence ridge alignment [11]. Abnormal dermatoglyphic pattern have been observed in several non-chromosomal genetic disorders or other diseases whose etiology may be influenced directly or indirectly by genetic inheritance [12]. There are thousands of diseases known to be caused by abnormal genes. If there is any abnormality in the genetic makeup of parents, it is inherited to the children and is reflected in dermatoglyphic patterns. It has been observed that dermatoglyphic shows definite diagnostic changes in those disorders which show genetic basis[7].

The dermatoglyphic ridges are differentiated in their definitive forms during third and fourth month of foetal life and once formed remain permanent and never change throughout the life except in the dimension in proportion to the growth of an individual. The original ridge characteristics are not disturbed unless the skin is damaged to a depth of about one millimeter [7]. Development of dermatoglyphic pattern is under genetic control. This is evident from the clear resemblance of dermatoglyphics among related person[13]. Dermatoglyphics as a diagnostic aid is now well established in a number of diseases, which have a strong hereditary basis, and is employed as a method of screening abnormal anomalies [14].The research findings put forth by some scientists suggest that muzzle prints of animals similar to fingerprints in human being could be used as permanent method of identification of such animal to check fraud particularly in insurance matter [15].

Medical interest in dermatoglyphics developed only in the last few decades and knowledge of the type of deviations associated with various medical disorders can add appreciably to the diagnostic armamentarium of the clinician. Diabetes, Congenital heart disease, Mongolism, Down's Syndrome, Schizophrenia, Leukemia, Thalassemia, are a few conditions to mention which utilized dermatoglyphics for its easy applicability, reproducibility, reliability, for early detection and management of high risk population. In this study, we found out some significant differences in dermatoglyphic parameters between males and females. This knowledge can be extrapolated in concluding that certain disorders are more common in particular sex.

Total Finger Ridge Counts (TFRC)

TFRC is the summation of the ridge counts from the fingers of both hands. In our study, the Total Finger Ridge Count (TFRC) was significantly more in males compared to females. Earlier work on gender classification based on the ridge density shows that the ridge density is greater for female than male [2,16,17,18] and G. G. Reddy analysed fingerprints of bagathas a tribal population of Andhra Pradesh (India) and showed the evident that the males showing higher mean ridge counts than females [19]. In a similar study in Philippines, Sally et al. found out that males have higher TFRCs than females [20].

A-B Ridge Counts

A ridge count is the number of ridges intervening between the triradius and the core or centre which cuts or touches a straight line joining these two points in a finger [21]. In our study, females had significantly higher a-b ridge counts than males. In a study by Hossein Rezaei Nezhad and Nasser Mahdavi Shah, there was no significant difference among the mean of a-b ridge between males and females [22].

In our study, there were no significant differences in the other parameters between males and females. Bhat GM et al conclude in their study that, in general, females have narrow ridges, more arches and fewer whorls. Females also have large frequency of hypothenar IV interdigital patterns [23]. Cummins et

al. established that males have coarser epidermal ridges than females [24]. Ohler and Cummins reported that males have a ridge breadth of 0.48 mm, whereas females have 0.43 mm, but none of them have included the furrow breadth [25]. This was taken into consideration by Moore who reported a higher value of ridge to ridge distance in males and thus a lesser ridge density as compared to females [26].

Based on the obtained results in our study, we can conclude that there are differences in dermatoglyphic parameters between women and men, and they can be used to determine the gender of the donor. This study can be used as a sorting parameter in cases where there are a large number of fingers prints available in case work analysis. The results from the study are quite encouraging and this ultimately would be helpful as a useful tool for the fingerprint experts either in the field of Forensic Science or law enforcement field [27].

Conclusion

From the present study, it appears that there do exists a variation in the dermatoglyphic patterns between male and female population. The method of identifying these variations is simple and inexpensive. Moreover the materials required for the dermatoglyphic procedure are easily available and portable. Identification by finger prints is infallible and now with the help with this study it will be further helpful to the fingerprint expert to direct their search to a particular gender and eventually the investigating officers would save time in nabbing suspects in a criminal case.

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