

IN THE NAME OF GOD

Dr. NIKOO DEHGHANIZADEH

FORENSIC MEDICINE SPECIALIST

- ◉ A NOVL APPROACH FOR SEX DETERMINATION
USING PALMAR TRI-RADII

- ◉ A PILOT STUDY

1. INTRODUCTION

- ◉ A 'palmprint' may be defined as the print of the inner surface of the hand (palm) between the fingers and wrist.
- ◉ Palmprints, along with fingerprints, are often encountered at the scene of crime i.e.
- ◉ at least 30% of the times, 1, 2 as either visible, latent or plastic prints.
- ◉ Palmprints are particularly useful from forensic point of view since it contain more features³ such as principal lines, minutiae, tri-radii, etc.

- ◉ The palm is divided by the principle lines into three areas:
- ◉ thenar (position next to the thumb),
- ◉ hypothenar (area towards little finger or ulnar bone side of the palm),
- ◉ and interdigital areas (beneath the fingers/digits).
- ◉ On the palm there are normally five tri-radii (also known as 'delta'); four (one each) are located in the inter-digital areas at the base of each finger and one lies near the wrist is known as the axial triradius.
- ◉ The position of the tri-radii serves as vital landmark for dermatoglyphic analysis of the palm.

- ◉ A study have been conducted on the effect of inbreeding on palmar dermatoglyphics in endogamous social groups while another study have been conducted on the ethnic variations.
- ◉ Several researchers had studied the link between palmar dermatoglyphics and certain diseases, medical conditions and disorders like
 - ◉ malocclusion, Vitiligo, leprosy, coronary artery disease, idiopathic epilepsy, etc.
 - ◉
- ◉ Some have considered sexual dimorphism using atd angle, epidermal palmar ridge breadth and palmprint ridge density, others have studied palmar patterns and other features like
 - ◉ a-b ridge count, atd angle, tad angle, tad angle, etc.
- ◉ The present work is aimed to determine sex from the study of distance between palmar tri-radii (abcd-t) in a heterogeneous population of central India.

2. METHODOLOGY

◎ 2.1. Inclusion & exclusion criteria

- ◎ Healthy adult individuals in the age group of 18 and 50 years were included in the study.
- ◎ The subjects with any apparent symptomatic
- ◎ disease, deformity, injury, fracture, amputation or history of any surgical procedures of the hand were excluded from the study.

◎ 2.2. Sample collection

- ◎ This pilot study was conducted on 300 bilateral palmprints collected from 150 healthy adult consenting individuals (75 males and 75 females) belonging to a heterogeneous population of central India (Table 1).

TABLE 1
**NUMBER OF MALES AND FEMALES AND
PALMPRINTS TAKEN FOR THE STUDY.**

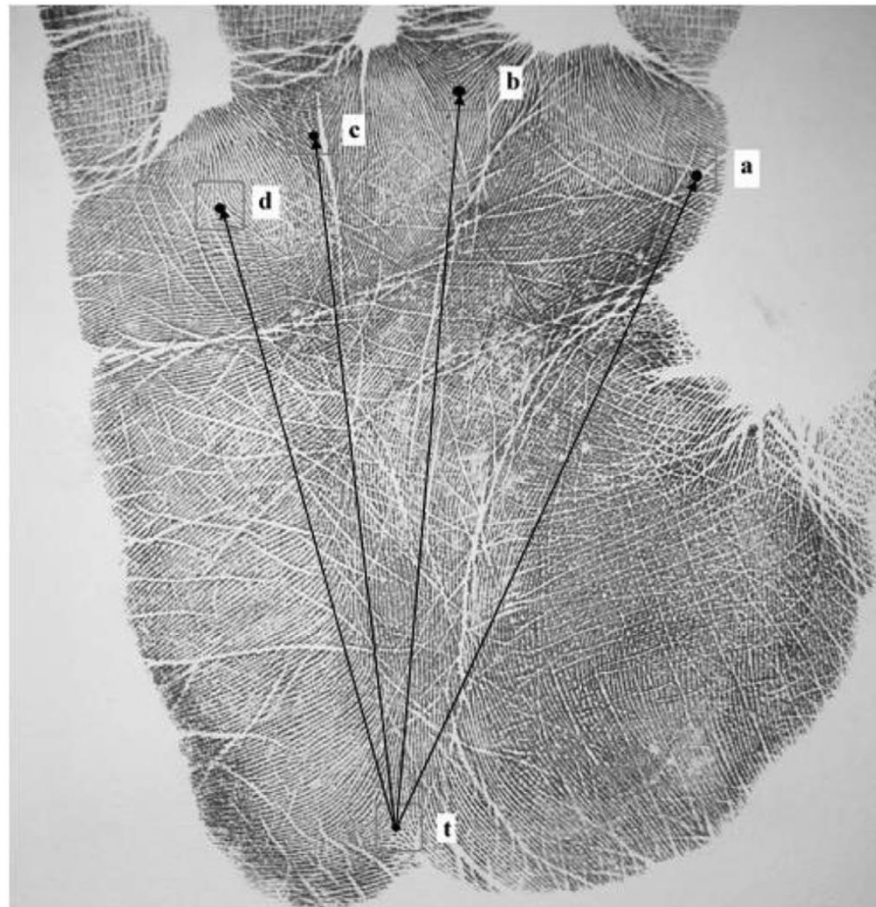
	MALE	FEMALE
PRINTS	75	75
TOTAL	150	150

- ⦿ The informed consent of the participating individuals was taken, after explaining to them the purpose of the study along with their rights according to the Helsinki declaration.
- ⦿ The selected individuals were asked to wash their hands clean with water and pat them dry.
- ⦿ A clean fingerprint plate was smeared with a requisite quantity of Kores® thumb impression ink black.
- ⦿ With the help of a rubber roller, it was spread uniformly to form a thin layer.
- ⦿ The subjects were then asked to apply the palms of both the hand one by one on the inked plate and then pressure was applied over the dorsal surface of the hands taking care that hollow of the palms and flexor creases over palms got inked uniformly.
- ⦿ Inked hands of the subjects were pressed on the sheet of the paper from proximal to distal end.
- ⦿ The palms were then lifted away from the paper in reverse order from distal to proximal end.

2.3. PARAMETERS OF ANALYSIS

- ◉ Different areas of palmprint; hypothenar (HT), Thenar (Th), first interdigital (I), second interdigital (II), third interdigital (III), and fourth interdigital (IV), were studied using handheld illuminated microscope.
- ◉ The tri-radial lying at the base of the index finger is termed as 'a'; at the base of middle finger is termed as 'b'; at the base of the ring finger is termed as 'c' and the one that lies at the base of the little finger is termed as 'd'.
- ◉ Generally, the axial triradius situated at the base of the fourth metacarpal bone near the proximal border of the palm near wrist and is termed as 't'.
- ◉
- ◉ The various palmar tri-radial i.e. 'a', 'b', 'c', 'd' and 't' were marked (Fig.1).

FIG. 1
(LEFT) PALMPRINT SHOWING THE FIVE PALMAR TRI-RADII NAMELY A, B, C, D AND T.



Representative Image not to scale

- The distances of the tri-radii a, b, c and d from the axial tri-radius 't' were measured using a scale.
- The readings obtained were tabulated and subjected to statistical tests.

STATISTICAL ANALYSIS

- ◉ Statistical analysis with the help of t-test was carried out using the simple T-Test calculator for independent means with a level of significance set at 0.05 and 0.01 levels.
- ◉ Posterior probability inferences of sex, based on abcd-t combined distances were made by calculating the likelihood ratio (LR) based on the Baye's theorem

3. RESULT AND DISCUSSION

- ◉ Out of the total, prints of 10 males and 12 females were not considered for the final result as they lacked the presence of any one of the five tri-radial. Hence, bringing down the total from 150 to 128 (65 males and 63 females).
- ◉ Descriptive statistics of the distances of the interdigital tri-radial 'a, b, c, d' to axial tri-radius 't' in male and female palmprints are shown in Table 2 and Table 3 respectively.

TABLE 2

Male (n=65)

Unit=centimeters

	Left palmprint				Total	Right palmprint				Total
	a-t	b-t	c-t	d-t		a-t	b-t	c-t	d-t	
Average	8.2	8.3	7.8	6.9	31.2	8.1	8.3	7.8	6.9	31.0
Minimum	6.2	5.8	5.4	4.3	21.7	6.1	5.7	5.0	4.2	21.4
Maximum	9.9	10.0	9.5	8.6	37.6	9.8	10.2	9.6	8.9	37.9
S.D.	0.81	0.99	0.98	1.02	3.66	0.89	1.04	1.10	1.14	4.06
S.E.	0.10	0.12	0.12	0.13	0.45	0.11	0.13	0.14	0.14	0.50
Range	6.2-9.9	5.8-10.0	5.4-9.5	4.3-8.6	21.7-37.6	6.1-9.8	5.7-10.2	5.0-9.6	4.2-8.9	21.4-37.9

S.D.=Standard Deviation, S.E.=Standard Error.

TABLE 3

DESCRIPTIVE STATISTICS: LEFT AND RIGHT PALMPRINT MEASUREMENTS IN FEMALES.

Female (n=63)

Unit=centimeters

	Left palmprint				Total	Right palmprint				Total
	a-t	b-t	c-t	d-t		a-t	b-t	c-t	d-t	
Average	7.3	7.4	6.9	6.2	27.9	7.4	7.5	7.0	6.2	28.1
Minimum	4.8	5.4	4.7	4.2	20.0	3.7	4.6	4.9	4.2	20.1
Maximum	8.9	9.0	8.4	8.0	33.3	9.2	9.1	8.6	7.8	34.7
S.D .	0.73	0.73	0.83	0.81	2.84	0.81	0.85	0.83	0.83	3.18
S.E.	0.09	0.09	0.10	0.10	0.36	0.10	0.11	0.11	0.10	0.40
Range	4.8-8.9	5.4-9.0	4.7-8.4	4.2-8.0	20.0-33.3	3.7-9.2	4.6-9.1	4.9-8.6	4.2-7.8	20.1-34.7

S.D.=Standard Deviation, S.E.=Standard Error.

- ◉ In males, the mean value of total distance between abcd-t in the left and right palm was 31.2 cm and 31.0 cm respectively.
- ◉ While, in females, the mean value of total distance between abcd-t in the left and right palm was 27.9 cm and 28.1 cm respectively.
- ◉ Males were found to have significantly higher distance than females in all the distances measured i.e., a-t, b-t, c-t, d-t and their sum i.e., abcd-t.
- ◉ Inter-observer and Intra-observer variability was found to be insignificant ($p > 0.01$).
- ◉ Also, there was an insignificant difference ($p > 0.01$ and $p > 0.05$) between the right and left palmar tri-radii abcd-t in males as well as females.

- ◉ Applying t-test, showed that there is significant difference between
- ◉ the left palmprint tri-radii abcd-t measurements at $p < 0.01$ level except
- ◉ the distance c-t of male vs b-t of female which was found to be
- ◉ significant only at $p < 0.05$ level and the distance d-t of male vs c-t of
- ◉ female which were found to be insignificant (Table 4).

TABLE 4

T-TEST: MALE VS FEMALE DIFFERENCES BETWEEN VARIOUS MEASUREMENTS OF LEFT PALMPRINTS.

Left Palmprint

Male	a-t		b-t		c-t		d-t	
Female	t-value*	p-value	t-value*	p-value	t-value*	p-value	t-value*	p-value
a-t	6.88159	<.00001	6.5863	<.00001	3.29822	0.001265	-2.15651**	0.032943**
b-t	5.70376	<.00001	5.54765	<.00001	2.25478**	0.025873**	-3.15975	0.001977
c-t	8.79041	<.00001	8.34923	<.00001	5.2342	<.00001	-0.01762++	0.985974++
d-t	14.20749	<.00001	13.16453	<.00001	10.05881	<.00001	4.61318	<.00001

* The result is significant at $p < 0.01$ level.

** The result is significant at $p < 0.05$ level.

++ The result is not significant at $p < 0.01$ & $p < 0.05$ level.

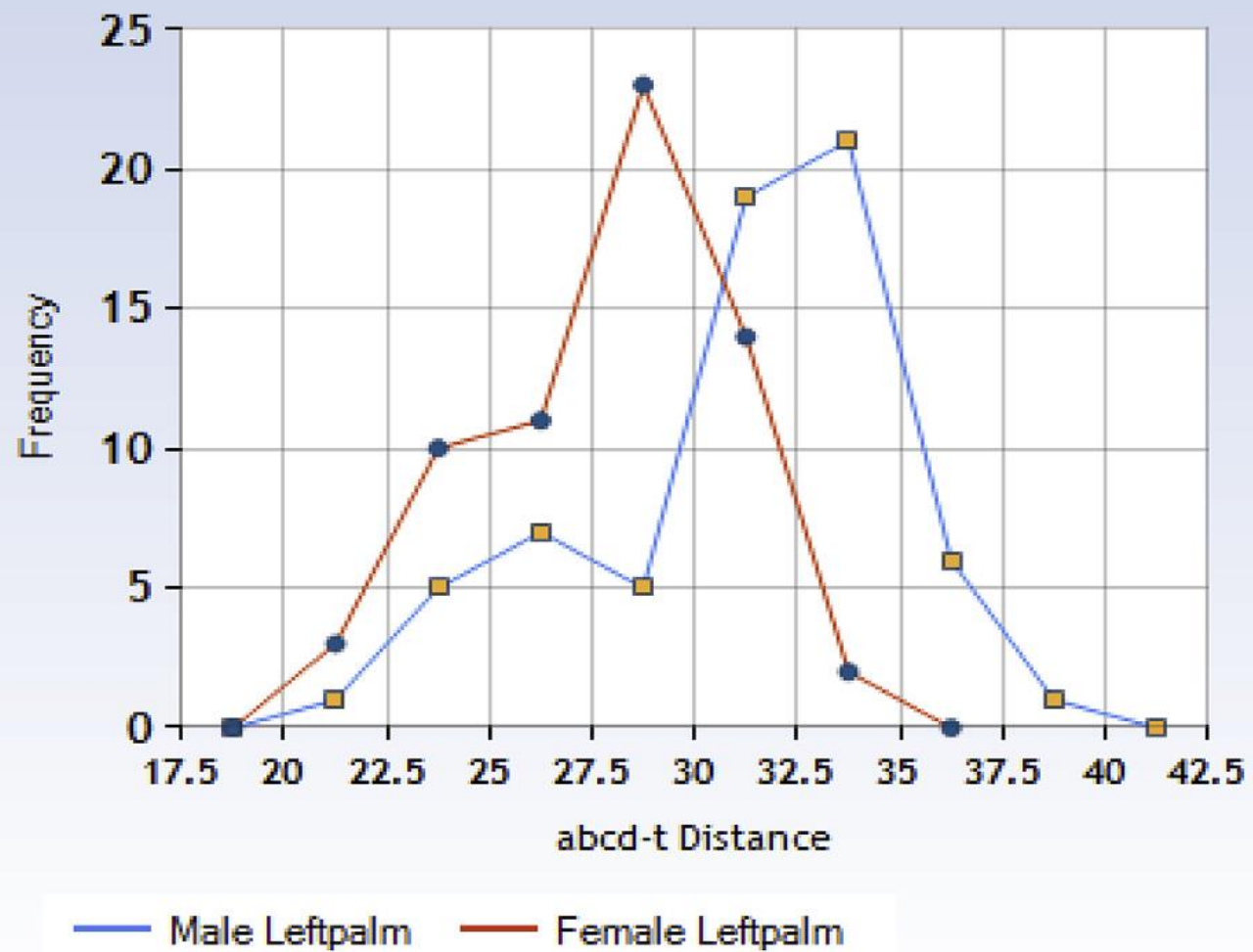
- ◉ Applying t-test, showed that there is significant difference between
- ◉ the right palmprint tri-radii abcd-t measurements at $p < 0.01$ level
- ◉ except the distances c-t of male vs a-t of female which was found to be
- ◉ significant only at $p < 0.05$ level; and the distance c-t of male vs b-t of
- ◉ female; and d-t of male vs c-t of females were found to be insignificant (Table 5).

TABLE 5
**T-TEST: MALE VS FEMALE DIFFERENCES BETWEEN
VARIOUS MEASUREMENTS OF RIGHT PALMPRINTS.**

Right Palmprint								
Male	a-t		b-t		c-t		d-t	
Female	t-value*	p-value	t-value*	p-value	t-value*	p-value	t-value*	p-value
a-t	4.8413	<.00001	5.13553	<.00001	2.11182**	0.036677**	-3.15544	0.002005
b-t	4.20049	0.00005	4.55016	.000012	1.60145++	0.111782++	-3.56743	0.000511
c-t	7.55204	<.00001	7.62101	<.00001	4.543	0.000013	-0.72817+	0.467858++
d-t	12.42386	<.00001	12.07981	<.00001	8.83466	<.00001	3.44862	0.000767
* The result is significant at $p < 0.01$ level.								
** The result is significant at $p < 0.05$ level.								
++ The result is not significant at $p < 0.01$ & $p < 0.05$ level.								

- ◉ The frequency distribution of the sum of the abcd-t distances of the
- ◉ male-female left and right palmprints are shown in Fig. 2 and Fig. 3
- ◉ respectively (Table 6 and Table 7).

**FIG. 2. FREQUENC
ABCD-T.**



**FIG. 3. FREQUENCY DISTRIBUTION MALE VS FEMALE RIGHT PALMPRINT TOTAL
DISTANCE
ABCD-T.**

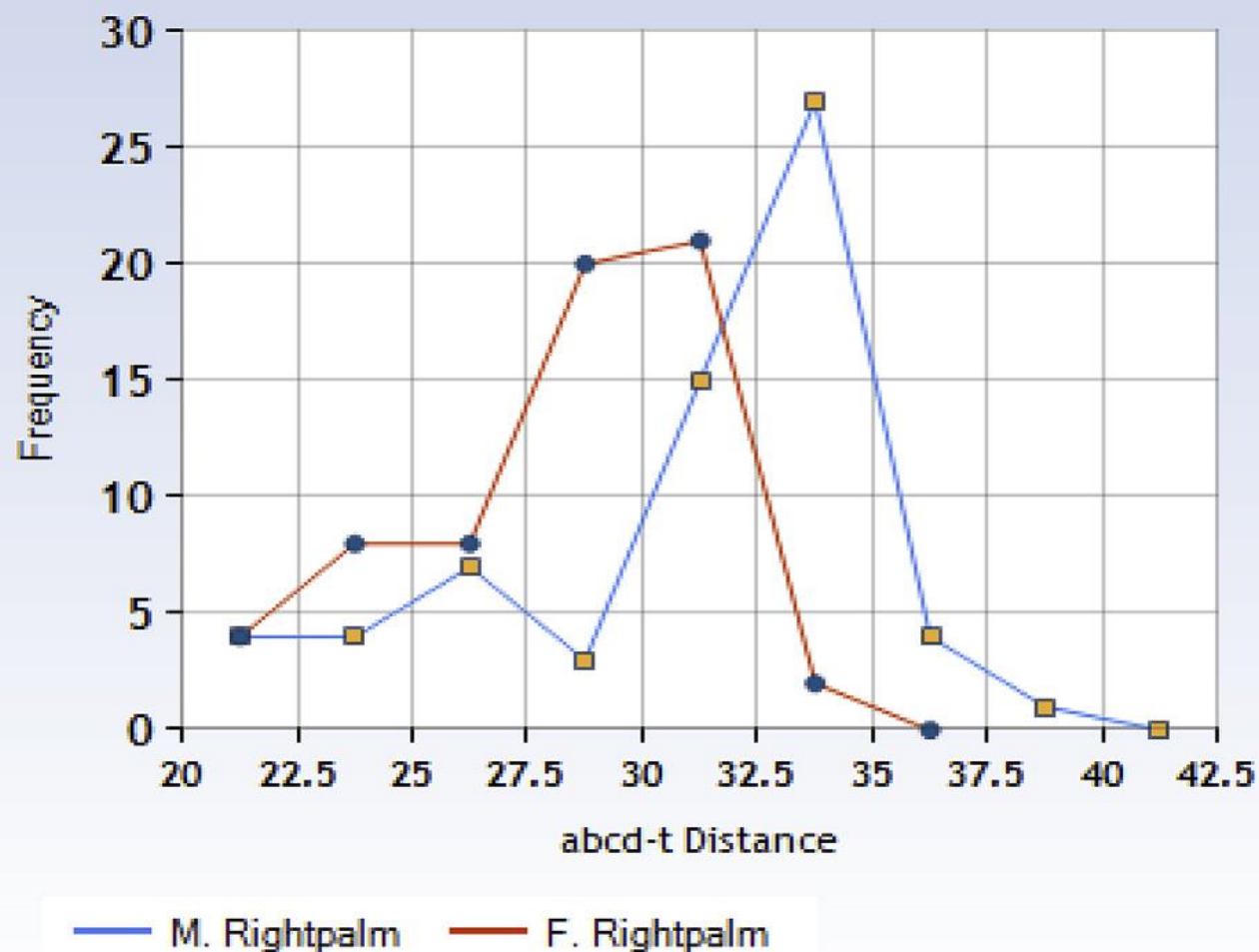


TABLE 6
**FREQUENCY DISTRIBUTION OF THE COMBINED ABCD-T
 DISTANCE IN MALE AND FEMALE LEFT
 PALMPRINTS.**

Combined Distance abcd-t (in cm)				
	Male Left Palmprint		Female Left Palmprint	
	Count	%	Count	%
20-22.4	1	1.5	3	4.8
22.5-24.9	5	7.7	10	15.9
25-27.4	7	10.8	11	17.5
27.5-29.9	5	7.7	23	36.5
30-32.4	19	29.2	14	22.2
32.5-34.9	21	32.3	2	3.2
35-37.4	6	9.2	-	-
37.5-39.9	1	1.5	-	-

TABLE 7
**FREQUENCY DISTRIBUTION OF THE COMBINED ABCD-T
 DISTANCE IN MALE AND FEMALE
 RIGHT PALMPRINTS.**

Combined Distance abcd-t(in cm)				
	Male Right Palmprint		Female Right Palmprint	
	Count	%	Count	%
20-22.4	4	6.2	4	6.3
22.5-24.9	4	6.2	8	12.7
25-27.4	7	10.8	8	12.7
27.5-29.9	3	4.6	20	31.7
30-32.4	15	23.1	21	33.3
32.5-34.9	27	41.5	2	3.2
35-37.4	4	6.2	-	-
37.5-39.9	1	1.5	-	-

- For the combined distance (abcd-t),
- the statistical analysis of the likelihood ratio and the odds ratio showed
- that in the left palmprint, a distance of less than 30 cm is more likely to
- be that of female origin ($p=0.96$) and a distance of more than 32.5 is
- most likely to be that of male origin ($p=0.99$) (Table 8).

TABLE 8
PROBABILITY DENSITIES AND LIKELIHOOD RATIOS DERIVED FROM THE
OBSERVED COMBINED
ABCD-T DISTANCE IN LEFT PALMPRINTS.

Combined Distance Left Palm abcd-t					
odd	Probability density		Likelihood ratio		Favored
	Male (C)	Female (C')	C/C'	C'/C	Male Female
20-22.4	0.02	0.05	0.3125	3.2000	0.10 < 0.90
22.5-24.9	0.08	0.16	0.4843	2.0649	0.23 < 0.77
25-27.4	0.11	0.18	0.6171	1.6204	0.38 < 0.62
27.5-29.9	0.08	0.37	0.2110	4.7403	0.04 < 0.96
30-32.4	0.29	0.22	1.3153	0.7603	0.58 > 0.42
32.5-34.9	0.32	0.03	10.0938	0.0991	0.99 > 0.01
35-37.4	0.09	0.001	92	0.0109	0.99 > 0.01
37.5-39.9	0.02	0.001	15	0.0667	0.99 > 0.01

- For the combined distance (abcd-t), the statistical analysis of the likelihood
- ratio and the odds ratio showed that in the right palmprint, a distance $\leq$
- 30 cm is more likely to be that of female origin ($p=0.98$) and
- a distance ≥ 32.5 is most likely to be that of male origin ($p=0.99$)
- (Table 9).

TABLE 9
**PROBABILITY DENSITIES AND LIKELIHOOD RATIOS DERIVED
 FROM THE OBSERVED COMBINED
 ABCD-T DISTANCE IN RIGHT PALMPRINTS.**

Combined Distance Right Palm abcd-t					
Favored odd	Probability density		Likelihood ratio		
	Male (C)	Female (C')	C/C'	C'/C	Male
Female					
20-22.4 0.94	0.06	0.06	0.9692	1.0317	0.06 <
22.5-24.9 0.77	0.06	0.13	0.4846	2.0635	0.23 <
25-27.4 0.72	0.11	0.13	0.8481	1.1791	0.28 <
27.5-29.9 0.98	0.05	0.32	0.1454	6.8783	0.02 <
30-32.4 0.52	0.23	0.33	0.6923	1.4444	0.48 <
32.5-34.9 0.01	0.42	0.03	13.0846	0.0764	0.99 >
35-37.4 0.01	0.06	0.001	62	0.0163	0.99 >

- ◉ For left as well as right palm prints, posterior probability using
- ◉ Baye's theorem shows that a combined distance of ≤ 30 cm will have a
- ◉ higher probability of belonging to a female ($p=0.99$). Similarly, a
- ◉ combined distance of ≥ 32.5 cm will be more indicative of males
- ◉ ($p=0.99$).

- ◉ The difference in the measurements may be due to the variation in
- ◉ height of males and females, and thus the overall palm and palmprint
- ◉ dimensions. Due to the distinct and novel parameters used, the results
- ◉ of the present work cannot be compared per se with other studies.

4. CONCLUSION

- ◉ A complete palmprint if encountered would mostly divulge the hand (left or right) to which the print belong²³ but sex identification is quite difficult.
- ◉ In the present study, we studied the distance between palmar
- ◉ tri-radii abcd-t, individually as well as combined in bilateral palmprints of males as well as females.
- ◉ Significant differences were found in the studied male and female samples.
- ◉ It thus may be helpful in ascertaining the sex of the donor of the palmprint found on the crime scene.

- ◉ If an unknown palm print is found at the scene of crime, the palm print may be developed/lifted using standard method(s).
- ◉ The palmar tri-radii (deltas) would be located. The distance between the palmar tri-radii (deltas) 'a', 'b', 'c', 'd' to the axial tri-radius 't' would be measured individually as well as combined.
- ◉ As per the results of the current pilot study, a combined distance of ≤ 30 cm will have a higher probability of belonging to a female donor ($p=0.99$) while, a combined distance of ≥ 32.5 cm will be more indicative of the print belonging to a male donor ($p=0.99$).
- ◉ Palmprint dermatoglyphics is vast and interesting area which needs
- ◉ to be explored further to be able to apply in routine forensic investigations.
- ◉ The works on various other parameters along with stature is in progress.

**THANKS FOR YOUR
ATTENTION**