Sexual Dimorphism from Fingerprint Ridge Density among KagayAnons of Philippines for Forensic Application

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Abstract

Hand morphology and fingerprint patterns form a valuable tool for person identification. Sex identification is a vital role in forensic and medico legal investigations. Determination of sex or gender of an individual is important because it can help in the forensic investigators to identify the suspect if male or female based on the ridge density of handprint or palm print. The present study used fingerprints collected fromKagay-anon population for determination of gender through ridge density. A total of 4000fingerprints (200 males and 200 females) were collected and analyzed using the "Acree" method of ridge density counting within 5mm x 5mm square area calculated the ridge density. The mean ridge density iscomparatively higher in females (12.39-14.14) than males (11.06-11.87) in the fingerprints of the study population. The results are presented in the form of tables and graphs.

Key words: *Forensic science, fingerprint, ridge density, sex, Kagay-anon, Philippines*

Introduction

In our day today life, so many crimes are reported that involved murder, terrorism, burglary, and sometimes natural disasters such as earthquake, floods causing mass fatalities. During the investigation at the crime scene, the suspect or perpetrators tend to leave their identity in the form of physical evidence, that can be used to link the crime and suspects or criminals. Physical evidence such as fingerprint, footprint, bloodstains, paint, and seminal stains have been used for person identification[1-2]. Hand morphology and fingerprint patterns form a valuable tool for human identification. Fingerprint is unique where it has their own pattern that are constituted by the ridges on the surface of fingers. The friction ridge pattern presents on fingers, palms,soles, andtoes remain unchanged throughout their life[3]. In the crime scene, determination of gender is the initial step in the investigation process that ease the investigators and impression evidence such as fingerprint, handprint and footprint are found useful in gender determination[4]. Some researchers have developed formulae to estimate the stature from fingerprint, handprint, and hand anthropometry during the process of crime investigation [5-7].Recently researchers have been conducting study on sexual dimorphism from footprint, toe print, fingerprint, and palm print ridge density [8-11]and the researchers aware the fact that ethnicity should be considered whenever conductinganthropological based research. Therefore, present study was aimed to study on sexual dimorphism from fingerprint ridge density among Kagay-anon population, an indigenous ethnic group in Philippines.

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Methodology

The study sample consists of 400 Kagay-anon

people living in Philippine. Out of 400 study subjects, 200 are males and 200 are females with age ranged from 18 – 65 years. Subjects with hand disorder or disease were excluded from this study. Kagay-anon people is an indigenous ethnic group that reside at Cagayan de Oro City in Philippines. An informed consent from the participants and ethical approval from MSU obtained. Before sample collection, subjects were advised to wash their hands and dry. Using a plain clean glass plate, fingerprint roller, fingerprint ink, the fingerprints were collected in A4 size white papers by inking technique as done in earlier research [10-11].

Five designated areas were taken from the tip of the fingerprints for this study. The radial area in the fingerprint was used to study ridge density. The five areas in right sidesare thumb (R1), index finger (R2), middle finger (R3), ring finger (R4) and little finger (R5). Similarly, the left-hand fingerprints are designated as L1, L2, L3, L4, and L5. Ridge density count was conducted and analyzed using "Acree" method in which a square box of 5mm x 5mm was drawn on transparent film and placed on designated areas for counting[12].A linentester, strongmagnifier (Figure 2), was used to count theridges. The values that obtained represents the ridge density in 25mm² area and the data were statistically analyzed using SPSS software, version 25. Student's t test was used to study the gender variation in the designated areas.

Figure 1: Five designated areas on right fingerprintsR1: thumb, R2: index finger, R3: middle finger, R4: ring finger, R5: little finger

Figure 2: Linen tester used

Results

Table 1 shows the meanfingerprint ridge density and standard deviationsamong male and female fingerprints of the participants. The study examined 1000 right and 1000 left fingerprints. The result indicated that the mean ridge density of male ranged from 11.06 to 11.87 while female from 12.39 to 14.16. The female ridge density is comparatively higher than males. The ridge density of the left hand and right hand is not same in both gender and showing bilateral asymmetry. The ring finger reflected higher ridge density than other fingers in both genders.

Table 1: Descriptive statistics for fingerprint ridge density among Kagay-anon population(Males= 200, Females = 200)

Right fingers	Mean		SD		Left fingers	Mean		SD	
	Right side					Left side			
	M	F	M	F		M	F	M	F
Thumb (R1)	11.48	13.28	1.64	1.89	Thumb(L1)	11.57	13.38	1.77	2.18
Index finger (R2)	11.34	12.64	1.68	1.90	Index finger (L2)	11.17	12.49	1.52	1.75
Middle finger (R3)	11.40	13.03	1.99	1.93	Middle finger (L3)	11.41	12.99	1.53	2.17
Ring finger (R4)	11.87	14.16	1.61	2.03	Ring finger (L4)	11.61	13.91	1.77	2.19
Little finger (R5)	11.21	12.87	1.57	2.07	Little finger (L5)	11.06	12.39	1.78	1.89

M: Male, F: Female, SD: Standard deviation, R1-R5: Right fingerprints, L1-L5: Left fingerprints

Figure 1 and 2 shows the mean ridge densities of the designated area in both sides among male and females. It showed that the mean finger ridge density is higher in female than male.

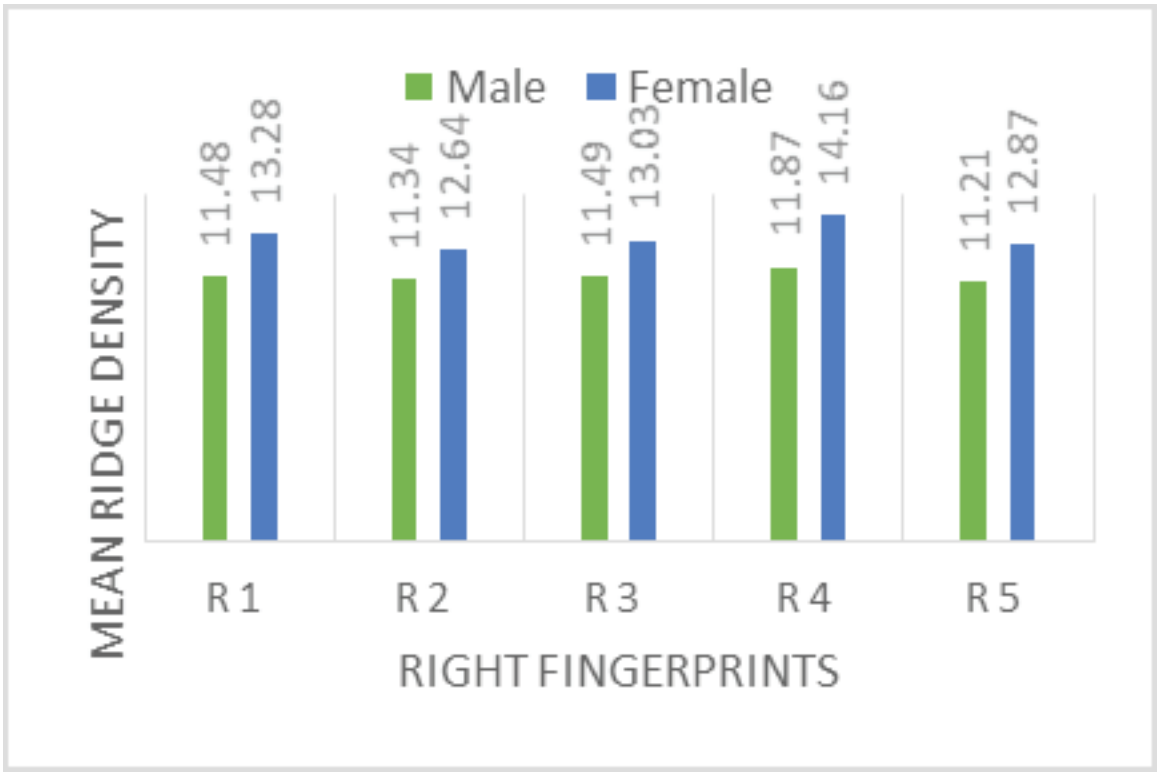

Figure 3: Mean ridge density in rightfingerprints

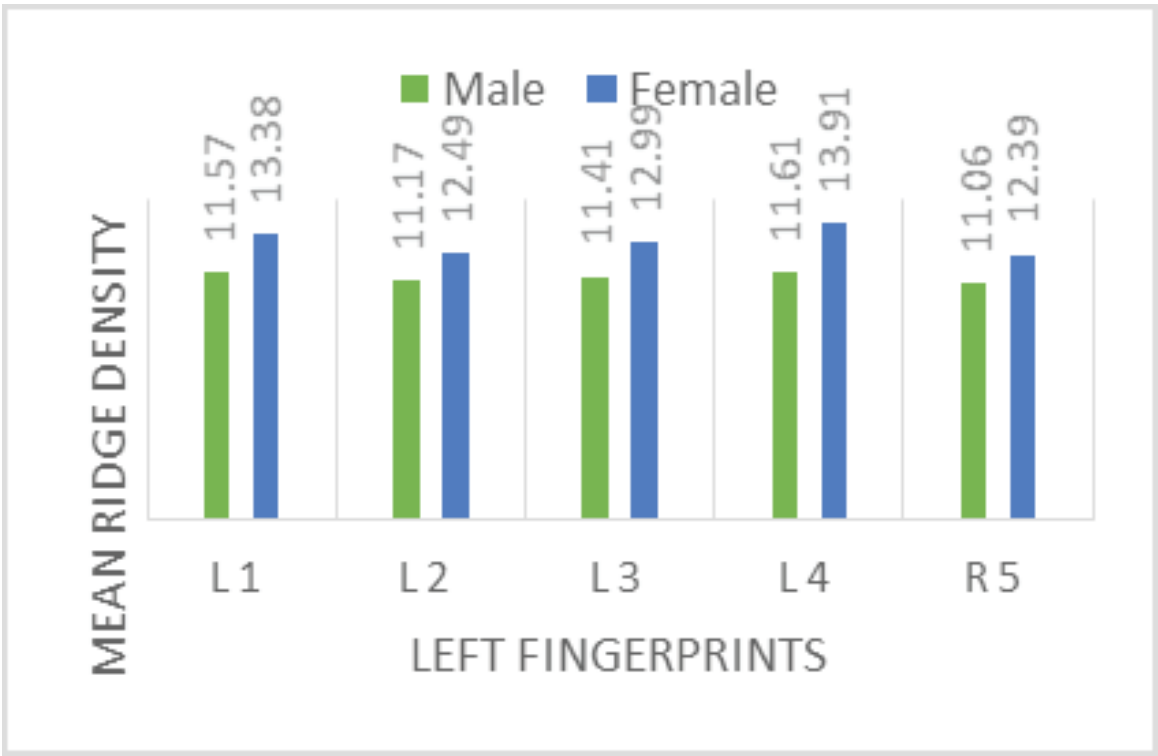

Figure 4: Mean ridge density in left fingerprints

Table 2: Sex differences in ridge density

Fingers	Right Finger		Left Finger	
	t value	*p* value	*t* value	*p* value
1	10.14	0.000*	9.10	0.000*
2	7.26	0.000*	8.03	0.000*
3	8.27	0.000*	8.39	0.000*
4	12.33	0.000*	11.57	0.000*
5	9.06	0.000*	6.76	0.000*

**p* is significant at the 0.01 level (2-tailed)

Table 2 showed that the *p*-values were found to be lesser than 0.01 and statistically significant. Sex differences found to be maximal in L4,R4and minimal in R2, L5.

Table 3 shows the frequency distribution of mean fingerprint ridge density in Kagay-anon population. 64% of males have a ridge density of 11 or lesser than 11, while 80% of females have 12 and above. From the frequency distribution mean of fingerprint ridge density, probability densities and likelihood ratio were calculated using Bayes' theorem. Assuming the probabilities of 50%, the odd was calculated.

The probability density and likelihood ratio based on Kagay-anon population was shown in Table 4. A ridge count of 10 ridges/25mm ² is more likely to be male (p=0.79) whereas ridge density of 13 ridges/25mm ² is more likely to be female (p=0.77). There is a high probability that fingerprint ridge density with 9 or lesser ridges to be male (p=1.00) and high probability of handprint ridge density with 14 or more ridges to be female (p=1.00).

Table 3: Frequency distribution of mean handprint ridge density of Kagay-anon population

Mean ridge density range	Male	Female
≤ 8	2	0
8 – 8.99	6	0
9 - 9.99	19	0
10 – 10.99	38	10
11 – 11.99	63	30
12 – 12.99	56	51
13 – 13.99	16	56
14 – 14.99	0	37
15 – 15.99	0	13
16 – 16.99	0	2
17 – 17.99	0	1
Total	200	200

Table 4: Probability densities and likelihood ratio in the handprint of Kagay-anon population

Ridge count	Probability density		Likelihood ratio		Odds
	Male (C)	Female (C')	(C)/ (C')	(C')/(C)	Male = 0.5, Female = 0.5
≤ 8	0.010	-	-	-	1.00 ≥ 0.00
8	0.030	-	-	-	1.00 ≥ 0.00
9	0.095	-	-	-	1.00 ≥ 0.00
10	0.190	0.050	3.800	0.263	0.79 ≥ 0.21
11	0.315	0.150	2.100	0.476	0.68 ≥ 0.32
12	0.280	0.255	1.100	0.912	0.52 ≥ 0.48
13	0.080	0.280	0.286	3.500	0.22 ≤ 0.77
14	-	0.185	-	-	0.00 ≤ 1.00
15	-	0.065	-	-	0.00 ≤ 1.00
≥16	-	0.015	-	-	0.00 ≤ 1.00

Discussion

Individualidentification isa mainstay in forensic investigation and impression evidence like fingerprint, footprint, palmprintor toe prints are playing a vital role for gender determination. Dermal friction ridges that present on finger or palmer appears during our intrauterine life and remains unaltered until death[13]. KagayAnons are people living mostly in Cagayan De Oro, Philippines. Cagayan De Oro region is noted for the tourists[14]. As a well-known biometric, fingerprint is globally used for identification of live and dead.Fingerprint patterns were studied to understand the inheritance factor that may find use in crime scene application [15-17].

A friction ridge is a raised portion of the epidermis on fingers, toes and palm or sole consisting of one or more connected ridge units of friction ridge skin. Ridge density study is the latest tool used for gender determination for various populations and hence researchers are showing interest in gender determination from footprint, fingerprint, toe print and palm print ridge density.Earlier period, the chance fingerprints were lifted by the fingerprint experts from the crime scenes like house breakings, homicides, sexual assaults and then compared crime scene prints with the fingerprints in the records by using hand magnifier. In the advance of science, currently automated fingerprint identification system (AFIS) is used. It is a process of using a computer match the crime scene fingerprints against the database. In the data base, the fingerprints of ex-convicts and suspects were recorded for criminal identification purposes.

But there are instances, wherein the involvement of first offender in crime involvements pose challenges in the AFIS, since the first offender fingerprints are not found in the system and the crime scene fingerprint is

questionable. In such complicated scenarios, the gender determination from fingerprint ridge density paves a way to investigation. Initially, the gender can be determined by using ridge density followed by stature determination and finally individual identification. The total ridge count could be influenced by the genetic components of individual such as sex chromosome, particularly in Y-chromosome[18]. In this study, radial area was chosen forridge density calculation.

The present study shows the mean ridge density for female is 13.11 while male is 10.27. Sudanese population study showed the mean ridge density for female has 14.50 while male 12.80[19].Another ridge density study on Filipino population showed that the ridge density for female and male were 15.89 and 14.57, respectively. Again, it is scientifically proved that ethnicity is a key component to be considered in the ridge density study on gender determination.

Some of the crime scene investigators have been underestimating the value of footprint, handprint and fingerprint evidence and neglected it from the initial stage of investigation[20]. This is because of the lack of knowledge on investigatorsabout the value of physical evidence found in crime scenes.

Conclusion

It is concluded that the present study done on Kagay-anon population revealed that there is existence of sexual dimorphism from the fingerprint ridge density. The result from fingerprint ridge density may be used as acorroborative evidence in the initial stage of investigation for person identification.

The present fingerprint ridge density study conducted on Philippine Kagay-Anon population, form a data base for gender determination. The ridge density results are different from other population hence can be used in real crime scenes for identification.

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