CHAPTER -I

INTRODUCTION

Like fingerprint, footprints are distinct physical characteristics that never changed in the life time of a person.sex identification is a key factor in crime scene investigation. Footprint forms a valuable clue for identification. Ridge density refers to the number of friction ridge in particular demarcated areas. Ridge density shows forensic significance for sexual dimorphism and ethnicity should be considered whenever conducting anthropological investigation. The present study was aimed to investigate the sex variation in footprints among Kerala population. (1)

Friction ridge patterns are considered unique to an individual and remain unchanged throughout life; thus fingerprints and footprints are used in forensic investigations for identification purposes. Finger prints and foot prints are being utilized by the anthropologist and forensic scientists for numerous purposes. Currently footprint is considered as a biometric technique used to obtain multiple information in crime scenes. Footprint is an important and valuable physical evidence found in many of the crime scenes, in particular homicides and burglary cases. Friction ridge density refers to the number in a defined area on a print or mark. (1)

Many studies were conducted on sex determination ridge density of fingerprint, palm print, and footprint. Footprints found in crimes are used to estimate stature and bodyweight for person. It is an established facts that footprints show various individual characteristic features to link the crime and criminals. Gender determination of a footprint becomes critical requirement in solving crime. Earlier researchers have estimated gender based on metric analysis of footprint. The differences in ridge density between males and females may be a result of the overall dimorphism. (2)

The footprint data is seldom available in forensic and police department and hence the investigators have the choice of comparing the crime scene footprint with potential suspects only. In this aspect, gender difference in the ridge density in the footprint become relevant in current scenarios for person identification. Footprints prove more information than fingerprint. So far no study was conducted in Kerala regarding gender difference in footprint. The present study was aimed to investigate the sex determination in footprint ridge density among Kerala population. (2)

CHAPTER-II

LITERATURE REVIEW

Tanuj kanchan, Kewal Krishnan, Disha Prusty,Meghana Machado,2014

Heel- ball index: An analysis of footprint dimensions for determination of sex

Determination of sex from the foot prints recovered at crime scenes can help the investigation by narrowing down the pool of possible suspects. The present research studies the dimensions of the heel and the ball in footprints, and derives the Heel-Ball (HB) index from these foot dimensions with the aim to find out if the foot dimensions and the HB index exhibit sexual dimorphisms. The study was carried out on 100 individuals (50 males, 50 females) of Indian origin. Footprints were obtained from both feet of the study participants using standard techniques. Thus, a total of 200 footprints were obtained. The breadth of the footprint at heel (BBAL) and the breadth of the footprint at heel (BHEL) were significantly larger in males on the sides. Likewise, the derived HB Index was larger in males in both feet, but the differences were not statistically significant. The study concludes that though footprint dimensions can be used in the determination of sex, the HB index may not be utilized in sex determination from footprints.

Sarah Reel, Simon Rouse, Wesley Veron OBE, Partick Doherty ,2012

Estimation of stature from static and dynamic footprint

The ability to estimate accurately from known parameters is a fundamental aspect of science and is evident as an emerging approach in the area of footprints and stature estimation within the field of forensic identification. There are numerous foot dimensions that have been measured in the literature to predict stature with varying degrees of confidence but few studies have tried been measured in the literature to predict stature with varying degrees of confidence but few studies have tried to link the strength of estimation to anatomical landmarks. Such an approach is utilized in this study which estimates stature from the right footprint of sixty one adult male and female UK Participants. Static and dynamic footprints were taken from each volunteer using the inkless paper system. The prints were digested and twelve length, width and angle measurements were chosen for the analysis. The highest correlations with stature were shown to be the heel to fourth toe print for the static group of footprints(r=0.786, p-0.01), and the heel to fifth toe print in the dynamic footprints(r=0.858, p-0.01).collinearity statistics suggest the heel to fifth toe print length measurement is independent and not influenced by any other variables in the estimation of stature for dynamic prints.

Michael S.Nirenberg, Elzabath Ansert, Kewal Krishan, Tanuj Krishnan, 2019

Two dimensional metric comparison between dynamic bare and sock –clad footprints for its forensic implications

Footprints may be present at crime scenes as physical evidence. This pilot study compares two dimensional measurements of bare and sock –clad footprint to determine if significant differences or similarities exist .Dynamic footprints were collected from 30 males and 20 females between the ages of 20 and 61 years old using the identicator inkless shoe print model LE 25P system. A midgait protocol was employed for obtaining footprints. The fifth and sixth footprint of gait were collected for the right and left foot respectively, in both sock-clad and barefoot trials. The footprint measurements between sock-clad and bare footprints were compared. The results did not any significant difference. Significant differences were seen for the width measurements between bare and sock-clad footprints. These findings have forensic implications, particularly in criminal cases where it is unclear if a footprint impression is from a sock-clad or a barefoot.

Krishnan T. Kanchan, 2016

Identification: prints- footprints

Foot print evaluation is a widely used method for the determination of foot morphology, but its efficacy and validity are considered controversial. Dynamic footprints were obtained from both feet of 5,866 school-aged children (6-17 years old) to detect any foot changes during growth. The interpretation of the imprint was performed using a classification scheme consisting of 6 types of footprints. In this scheme, foot print types 1 and 2 represent the typical and intermediate high- arched foot, respectively. Types 3 and 4 represent normal foot variants, while type 5 corresponds to the low-arched foot and type 4 to severe flat foot, the latter often encountered in pathological conditions. There was statistically significant difference in footprint-type frequencies between boys and girls of ages 7, 9, 11, 14, and 15, which probably indicates the difference in growth potential of the foot between sexes. The proportion of high and low- arched foot types decreased with increasing age in both boys and girls .even though critical changes of the foot are believed to occur during pre-school development, this study shows that considerable changes also take place during school age and until late adolescence.

Panagiotis stavels, Theodoros B. Grivas, 2015

The evolution of foot morphology in children between 6 and 17 years of age: a cross sectional study based on footprints in a Mediterranean population.

Foot print evaluation is widely used method for the determination of foot morphology, but its efficacy and validity are considered controversial. Dynamic footprint were obtained from both feet of 5,866 school aged children (6-17 years old) to detect any foot changes during growth. The interpretation of the imprint was performed using a classification scheme consisting of 6 types of footprints. In these scheme, footprint types 1 and 2 represent normal variants, while type 5 corresponds to the low- arched foot, respectively. Types 3 and 4 represent normal foot variants, while type 5 corresponds to the low – arched foot and type 4 to severe flat foot, the latter often encountered in pathological conditions. There was statistically significant difference in footprint-type frequencies between boys and girls of ages 7, 9, 11, 14, and 15, which probably indicates the difference in growth potential of the foot between sexes. The proportion of high and low arched foot types decreased with increasing age in both girls and boys. Even though critical changes of the foot are believed to occur during pre –school development, this study shows the considerable changes also take pace during school age until late adolescence.

CHAPTER-III

AIM AND OBJECTIVE

AIM

The aim of the study is, to determine sex from footprint ridge density.

OBJECTIVES

- To examine the ridge count in male and female footprint.
- And to determine sex by using footprint ridge density.

CHAPTER-IV

MATERIALS AND METHADOLGY

MATERIALS

- Pre inked strip
- A4 sheet
- Magnifier

METHADOLOGY

The sample collection was conducted in Thrissur district in Kerala state. The study sample consisted of 200 samples (100 males and 100 females) with age ranges from 25 to 50 years. The footprints were collected using pre-inked strip. For ridge density counting, eight areas in footprint viz. center from five toes, medial ball, lateral ball and heel were chosen as shown in figure. 1. The eight areas were great toe(T1),2.Second toe(T2),3.Third toe(T3),4.Fourth toe(T4),5.Little toe(T5),6.Medial ball, the ball of great toe (MB),7.Lateral ball, below the triradius point on the ball of the 5th toe(LB) And 8.Heel, the central prominent part of the heel(H) for male and females. By using magnifier, the ridge density was counted by placing a transparent film of 5mm square on the areas on the areas and recorded findings. The observation was presented in tables and figures.)

CHAPTER- V

OBSERVATION

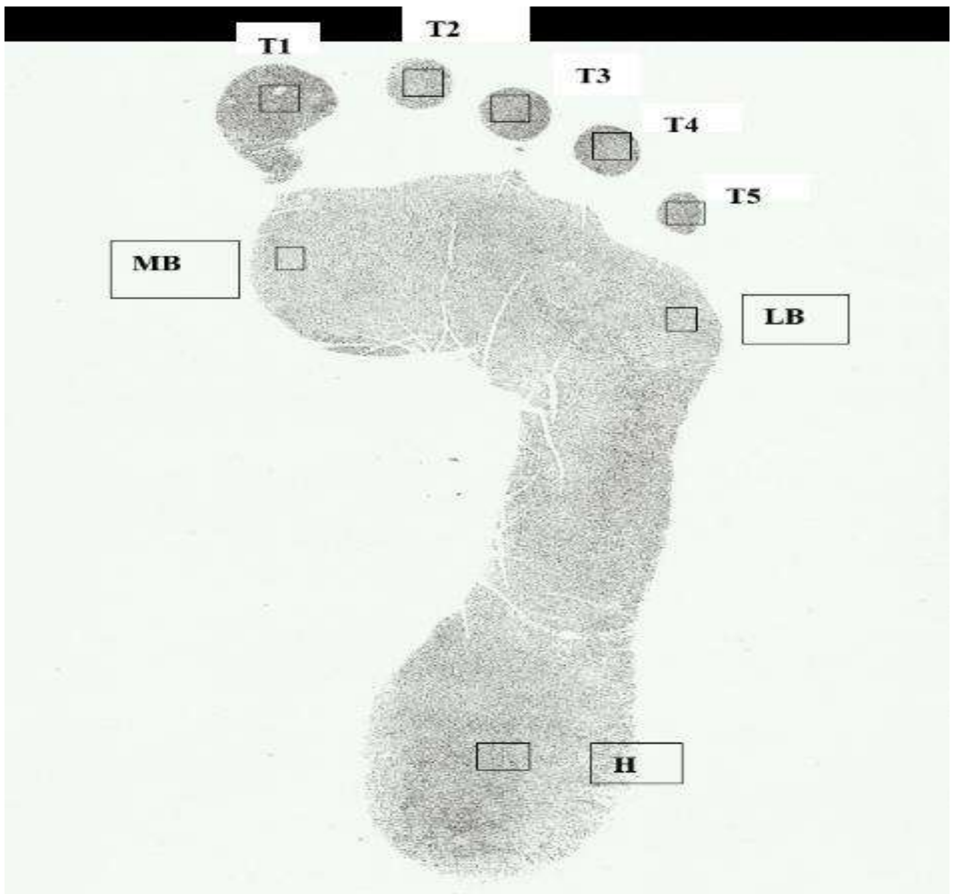


Figure 1: Designated areas (25 square mm area) for ridge density calculation on the footprints

Table 1 presents the descriptive statistics of ridge densities in eight areas, standard deviation and range. It is very interesting to note that the mean ridge density was higher in females than males in all designated areas in both side of feet.

Table 1: descriptive statistics of ridge density in footprints of both genders and sides (N=200)

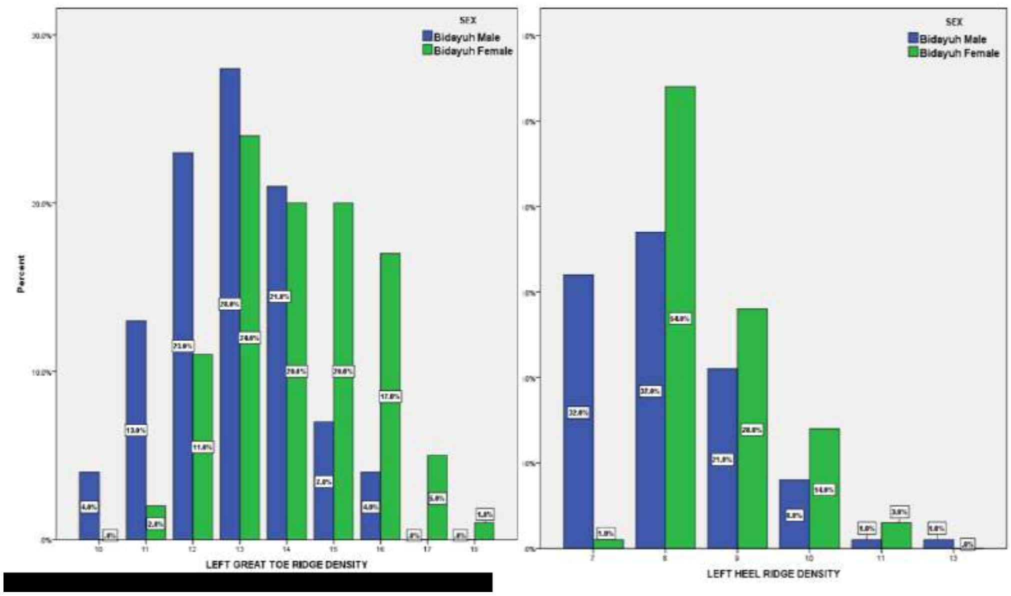
Designated areas	Sex M=100,F=100	MRD	SD	RANGE	MRD	SD	RANGE
Great toe,T1	Male Female	12.80 14.33	1.52 1.56	10-18 11-19	12.80 14.33	1.52 1.56	10-18 11-19
Second toe,T2	Male Female	12.86 14.56	1.40 1.76	10-16 11-19	12.93 14.56	1.49 1.95	10-16 11-21
Third toe,T3	Male female	13.41 15.61	1.72 1.56	10-18 11-20	13.63 15.54	1.63 1.69	11-17 11-17
Fourth toe,T4	Male Female	13.40 15.75	1.54 1.84	10-18 11-21	13.71 15.21	1.83 1.72	10-20 12-19
Fifth toe,T5	Male Female	13.06 15.80	1.48 1.59	8-16 12-20	13.71 15.21	1.36 1.60	10-17 12-19
Medial ball, MB	Male Female	10.88 11.81	1.03 1.22	8-14 10-15	10.91 12.11	1.12 1.25	8-12 10-15
Lateral ball, LB	Male Female	9.79 10.55	1.21 1.10	7-14 8-14	10.91 12.11	1.21 1.25	8-12 10-15

N= Sample size, M:Male; F: Female, MRD: Mean ridge density;SD: Standard deviation

Table 2: sex differences in footprint ridge density on the right and left sides

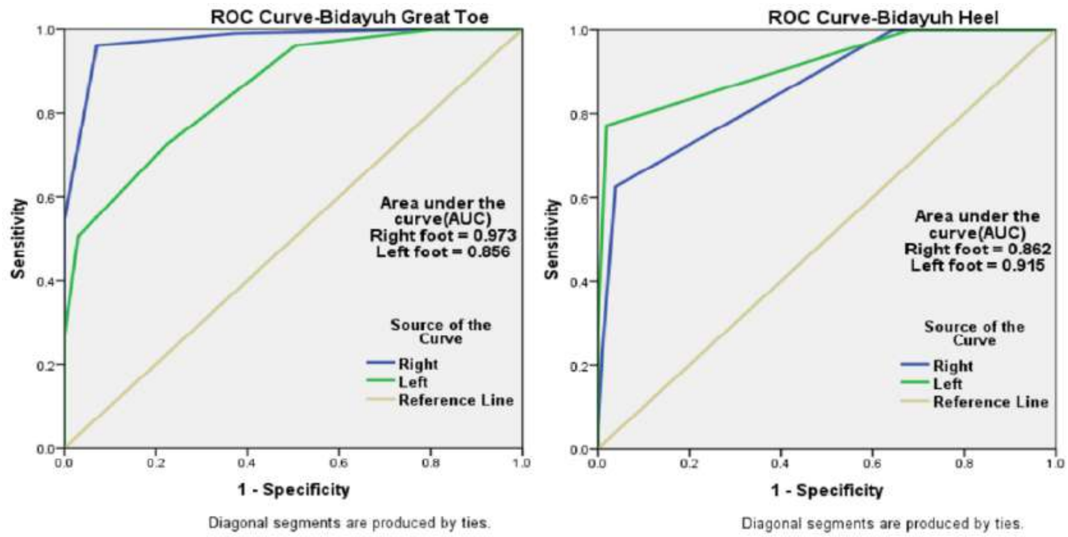
.

Areas	Right foot print t-value	Right footprint p-value	Left footprint t-value	Left footprint p-value
Great toe	7.021	0.000	6.501	0.000
Second toe	6.648	0.000	7.000	0.000
Third toe	8.117	0.000	9.473	0.000
Fourth toe	5.979	0.000	9.787	0.000
Little toe	6.801	0.000	9.301	0.000
Lateral ball	3.754	0.000	4.625	0.000
Medial ball	3.284	0.001	3.697	0.000



[redacted]

Graph 1: illustrative example of showing the footprint ridge density in left great toe and left heel. Blue colour indicates male and green colour indicates female



Graph 2: illustrative example of ROC curve for the footprint ridge density different regions of footprint

Table 3: person correlation(r) of toe print ridge density between different regions of footprint

	Right footprint r-value	Right footprint p-value	Left footprint r-value	Left footprint p-value
Great toe-medial ball	0.351	0.000	0.416	0.000
Great toe-lateral ball	0.251	0.000	0.260	0.000
Great toe-heel	0.312	0.000	0.195	0.000
Heel-lateral ball	0.374	0.000	0.092	0.000
Medial ball-lateral ball	0.216	0.000	0.258	0.000
Second toe-great toe	0.390	0.000	0.329	0.000
Third toe-great toe	0.541	0.000	0.349	0.000
Fourth toe-great toe	0.472	0.000	0.419	0.000
Little toe-great toe	0.345	0.000	0.422	0.000
Little toe-second toe	0.366	0.000	0.361	0.000
Little toe-third toe	0.462	0.000	0.479	0.000
Little toe-fourth toe	0.398	0.000	0.501	0.000
Third toe-second toe	0.324	0.000	0.542	0.000
Second toe-fourth toe	0.591	0.000	0.478	0.000
Fourth toe-third toe	0.428	0.000	0.626	0.000

The mean ridge density for females are higher than the males in all designated areas but the mean ridge density on third toe T3 in both genders show similar range,11-17. The table 2 shows that sex differences in footprint ridge density were found to be statistically significant in all eight areas of foot print in the study population. The interesting result finding in this population is that maximum sex difference were observed for the ridge density in all five toe areas than the ball and heel areas, ie left great toe and left heel as shown in figure 2.

Figure 2 shows the illustrative example of the footprint ridge densities in left great toe and heel. In statistics, a receiver operating characteristic curve (ROC) is a graphical plot that illustrates the diagnostic ability of binary classifier system as it discrimination threshold is varied. Here ROC analyses were used to the test the overall performance of the variables in sex determination. The higher the AUC, the better sex determination is variable. Based on the AUC in ROC analysis as shown in figure 3, it is observed that the sexing potential for the variable. Based on the AUC in ROC analysis as shown in figure 3, it is observed that the sexing potential for the great toe ridge density in the footprint was 97.3% on the right and 85.6% on the left foot while heel was 86.2% on the right and 91.5% on the left. Third toe sexing potential was 86.2% on the right foot and 97.0% for left , while fourth toe was 83.0% for right, 96.4% for the left and fifth toe sexing potential was 90.3% for right and 90.1% for left. The medial ball was 96.8% for the right and 86.2% for left while heel was 86.2% for the left while heel was 86.2% for the right and 91.5% for left.

CHAPTER-V

RESULT AND CONCLUSION

RESULT

The sex can be determined by using footprint ridge density.

CONCLUSION

The footprint ridge density of this population provided valuable information in sex determination. The result findings of ridge density of this population are entirely different from other populations and also reflected the ethnic variation. The study used eight areas in footprint for ridge density calculation and hence even the presence of partial footprints found in crime scene can be well explained the sexual dimorphism genetically in forensic terms.

CHAPTER-VI

REFERENCES

1. Nataraj moorthy T, Ang YL, Saufee AS, Nik F.

Estimation of stature from footprint and foot outline measurements in Malaysian Chinese. For Forensic investigation. Indo Journal legal Forensic Science 2016; vol-3 issue 4, page 1-5

2. Hariunnisa MAK, Nataraja moorthy.

Stature estimation from footprint anthropometric measurements of footprint among Melanaus; **An** indigenious population of Malaysian Boreno.Canadi Soc Forensic Science journal 2015; volume 4, issue 2, page 68-84

3. Paurbhi S, Baljeet Y.

Age, sex and stature estimation from footprint dimensions.Arab Journal forensic science vol -6, issue 2, page 497-507, 2015

4. SandeepVB, Anand BK.

Study of finger print pattern and gender distribution in and around Nanded district of Maharashtra state. Europe journal forensic science, 2017, vol-3, issue 7, page 1-5

5. Laura JH, Ashion MP, Robert S

Comparison of footprint ridge density between South African ethnic groups. Journal forensic investigation, 2016; vol -1, issue 4, page 1-4