

Comparison of Footprint Dimension Among Both Foot to Determine Gender

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Abstract

Footprints are one of the valuable physical evidence left by criminals in crime scene. Footprints are transferred to the crime scene depending on the “Locard’s Exchange” principle. It denotes that ‘every contact leaves a trace’. Footprints are similar to fingerprints in their uniqueness. They both have individual characteristics, so that no two people will have similar footprint patterns. In the previous studies, height, weight, and sex were estimated based on the footprint measurements. There are various measuring methods used to identify it. So, there are no studies related to the comparison of both footprints of human beings. The aim of this study is to compare both human footprints and determine Gender if there are any similarities between those. For this quantitative research, the samples will be collected from people in between the age group of 20 to 25 years. Because in that age group, a person will attain their maximum growth, once they attain their 25th age, the person will not have any maximum changes in their footprints. This is just a pilot study, so a total of 100 samples will be collected from the targeted people. The hypothesis of this study person will have maximum similarities between both footprints. So, we can easily identify the person by matching one footprint with the other footprints of the same person and identify gender. These comparison techniques can be further use to investigate the crime scene to identify the individual.

Keywords: footprint, similarities, gender.

Introduction

Footprint

Footprints are the impressions or images left behind by a person walking or running. Every person’s foot has a unique set of ridges that make up a print unmatched by any other human being. They may be caused by the bare foot, or may be left by footwear. As with fingerprints, the footprint’s pattern is a unique characteristic that can pinpoint to any one particular person. Footprints are transfer to the crime scene based on the Locard’s Principle of Exchange it denotes “Every contact leaves a trace”.

Bare footprint or Impression and shoeprint or impression is generally known as Footprint. They may be caused by bare foot, or may be left by footwear. These prints known as footwear prints. The value of such evidence will however proportionate to the points of identification, which can be demonstrated. It is characteristics that are unique in shape and detail, which must be looked for and studied.

Examination and comparison of design, size or shape of footprint is useful in criminal investigation for leading a case in appropriate direction. Several research has been carried out to prove that the foot prints are unique to a person and have high value in court of law. In foot prints the parameters that are taken into consideration are the dimensions of the stride, footprint's location, its size and shape, the angulations, interspaces, deepness, the outer margins, creases in heels, information regarding the gait pattern from the injuries and accidental damages, length of legs and height of the individual range of body weight and interrelated movement of the foot, ankle, leg and the body that are individualistic to that particular person.

Categories of footprints

The impressions of a footprint can be divided into two categories:

1. 2D (Two Dimensional)
2. 3D (Three Dimensional).

Two-Dimensional Footprint: When the underside of a shoe collides with a hard, flat, or plane surface, such as a tile floor or a concrete, this type of impression is created. The substance is frequently transmitted from the sole of the shoe to the ground. Those formed with moist dirt and blood, are known as positive impressions. A favourable impression is usually obvious. These are formed in the dust or on a surface that has been lightly waxed. If the footprint is produced by deposition of material like dust, dirt, oil, blood, colour powdery substances, etc., on smooth and hard surface, giving rise to a two-dimensional print, it is known as surface footprint. They are generally found indoors.

The two-dimensional prints can further be divided into two types:

- **Patent print:** A visible print is a transfer of material from the shoe or tire to the surface. This kind can be observed through naked eye without extra aids. Examples: Bloody shoe prints leftward on carpet or tracks left by muddy tires on a driveway.
- **Latent print:** A latent print is not easily observable to the bare eye. This is formed by static charges between the sole or tread and the surface. Investigators uses powders, chemicals and alternate light sources to observe these prints. Illustration comprise shoeprints identified on a tile or hardwood ground, window sill, or metal counter, or tire tracks detected on road surfaces, driveways or sidewalks.

Analysis of footprint:

Methods of analysis of footprints:

There are various studies have been conducted to determine the height, weight and stature of the person with their footprints. There are various measuring methods are used to identify it. There are several methods are available for the description and analysis of footprints the approaches can be classed in two groups; those using linear or metric measurements to connect the periphery of anatomical features of the footprint and those using a non-metric subjective assessment of the outline morphology of the print.

The linear measurement approaches for forensic footprint examination includes:

Gunn method

1. Extended Gunn method
2. Robbins diagonal and parallel method

Reel method

1. Rossi's podometrics method
2. Optical centre method
3. Overlay method

Gunn method:

The Gunn Method was devised by a forensic podiatrist from Canada, Dr. Norman Gunn. According to Gunn (1991), the Gunn method consist of constructing five lines diverging from the rearmost point of the heel to the distal tip of the phalanges of each toe and a sixth line constructed on the widest part of the foot, from the medical side of the ball to the lateral side of the foot. Once all the lines have been constructed, they are measured individually and a comparison can be made between known bare footprints and unknown footprint. It indicates that the Gunn method is applicable if the footprint is captured in its entire form.

Extended Gunn Method:

The Gunn method is applicable only if a complete form of the footprint is found and evaluated. In case, if there is a recovery of any partial footprint where the heel part of the footprint is missing or smudged due to any circumstances, then the technique used for analyzing the whole footprint will not be applicable. Therefore, an extended version of the same was established which involved the examination of the partial footprint. In this, the same series of six lines are sketched from any of the points acting as a reference to measure the lengths and the width of the foot. The method of comparison is same as that in case of the previously described system.

Reel Method:

The Reel method was devised by a leading forensic podiatrist in the UK, Dr. Sarah Reel, This method consists of the same lines as the Gunn method but, with the additional line, namely the heel widest point. The method uses a total of seven lines this method has been tested for reliability in assessing two-dimensional bare footprints and has proved to be robust. Currently, this method has been adopted by practitioners and bare footprint researchers as the best practice for evaluating two-dimensional bare footprints for research purposes or criminal casework.

Robbin's diagonal and parallel axis method:

The Robbins method was devised by an American forensic anthropologist Robbin's method allows for two methods to be used in combination, the diagonal method and the parallel axis method. These two approaches utilize visual anthropological measurements, some of which are the same as the Gunn method. The Robbins' method is capable of measuring both two-dimensional and three-dimensional bare footprints, marks or impressions, and allows for the length, width and angles to be measured.

A transparent metric grid is used to align the footprint vertically with a line in the centre of the footprint known as the Designated Longitudinal Axis (DLA) which provides the footprint with a zero-reference point. This method also allows for right-angled lines to be constructed from a theoretical baseline across the rearmost point of the heel to the furthest point of each toe. An additional line measuring the angle declination is constructed from the first phalanx to the fifth phalanx.

Rossi's Podometrics Method:

This method was devised by an American podiatrist, William Rossi (1992). Rossi's system was based on the placement of five longitudinal lines and five lateral lines through prescribed positions relative to the plantar surface of the foot with each set of lines converging at a central point. According to Rossi, quantitative data can be obtained from the Rossi method using angle and distances between intersecting points of the longitudinal and transverse intersecting lines. Each intersecting point can be used to map the shape of the foot.

Although Rossi did not envisage his methods to be used in the forensic evaluation of footprints, those working in the field of footprints saw this approach as having the potential to be utilized, although to date his methods do not appear to have been tested and used in practice. Again, this measurement method is

descriptive only and its validity as a singular measurement method for use in footprint examination is questionable.

Optical Centre Method:

The optical centre method was developed by the Royal Canadian Mounted Police in the 1990s. This method assigns an optical centre (most centre point) on any of the morphological features exhibited by the foot in question, a circle is placed in a position of best fit on each of the toes and the heel. Using the circle centre point, the Gunn method is then used to construct five lines from the central point of the heel to the central point of each toe and a single line of the width of the ball. The lines are measured and compared to an unknown and exemplar footprint. The direct drawing of the circles was not applied because it might damage the print so found.

This method used optical centers instead of lines joining the apex of the toes and heel. Several lines are created from these optical center points of the toe to the center points of the heel. Since no circles are possible around the medial and lateral part of the ball region therefore, they are kept like this with only one linear line measuring the width. A computer catalog is used to accumulate and compare the quantities from each shoeless impression.

Overlay Method:

The overlay method was developed in the UK by the Forensic Science Service. This method uses a traced outline of a known footprint instead of the linear measurement approach. To conduct a comparative analysis between known and unknown footprint, the outline of the known footprint is traced on to a clear acetate card and this is overlaid on to the unknown footprint. This analysis involves comparing the overall positions and characteristics of the two, to assess how best these features fit, and if the morphological outline is clearly represented.

Review of literature

1. Anthropometric examination of footprints in South Indian Population for sex estimation: done by Sravya Palla, Anitha Shivajirao (2024): The current study intended to ascertain an individual's sex, be it male or female, based on footprint evidence, which is a highly neglected research area. This study was part of an anthropometrical research in which seven different footprint measurements, specifically lengths and widths were recorded and statistically assessed to determine a person's sex from inked bilateral footprints of 132 individuals (61 males and 71 females) aged of 18-50 years, who were born in South India. Results noted that the dimensions of the right footprint were more accurate in determine the sex in comparison to the measurements of the left footprint among both sex.
2. The detection and identification of footprint impressions at the scene of crime – A mini review: done by Hafiz Muhammad Abbas Malik (2023): In order to identify the offender and solve a mystery crime like footprint, forensic investigators hunt for physical evidence at crime scenes or the place of the crime. In this review study they have mentioned about the examination of footprints and different techniques that will be used in collection and preservation of footprints. There were four main characteristics used to evaluate the footprints which included dimension, shapes, peculiarities and patterns. Although some collection approaches differ for print and impression, both individual spots and their combined pattern were helpful in identifying persons.
3. Detection of Footprint Impression at the scene of crime – A review study: done by Vijay Panchal and Rakesh Mia (2022): In this review paper, they highlighted the scientific method to easily analyze the footprint impression at the scene of crime. Techniques to analyze the footprint included crime scene

tracing, photography and lifting method and examination methods of footprint impressions included casting, holography and electrostatic technique. Individual principles and methods for the evaluation of marks were Dimension, Shapes, Patterns and Peculiarities. As per the study most recent techniques for collection of footprints like a hologram, electrostatics techniques, silicon casts are used.

4. A Review study on Age estimation from footprints: done by Arun Tiwari and Divya Bajpai Tripathy (2022): This was a review study for footprints generated on surfaces when a person walks, runs, jumps or stand on that surface. Foot prints were prepared under different condition. If the surface is soft or wet so in such circumstances the footprint of the man walking on him will be ready which is known as sunken foot print. Result of this study showed that by analysis of footprints, features like age, height, sex and gait pattern can be identified. Approximate number of criminals can be determined when the footprint of different structure are done at the crime scene.
5. Evidential value of footprints in criminal investigation: done by Harendra Nath Singh (2021): This paper primarily focuses on explaining the evidentiary value of footprints in criminal investigation. Footprint evidence is a source of physical evidence to identify the culprit in a criminal investigation. The collection, preservation, and analysis of this valuable physical evidence have become more frequent in the law enforcement community. This valuable evidence is over looked due to a lack of scientific training for proper searching of the crime scene. Presently it requires proper study, training and scientific interpretation of footprint evidence, so that investigation agency can identify the culprit and convict them in court of law.
6. Sex determination based on footprint ratio and comparison of toe print pattern in the male and female Nigerian students: done by Elijah, Gideon et.al., (2021): It measured the dimensions of foot prints, the maximum length and width of the foot. Sex determination was done by ratio of these measurements. The result had shown that the females have more whorl pattern and males have highest percentage of arch pattern. Sex determination by footprint ratio was carried out and the standard footprint ratio values of 0.371219 and 0.3737645 were obtained. 51% accuracy was obtained in sex determination using this method. Foot print ratio up to these values and below was predicted to be female while foot print ratio above these values were predicted to be male.
7. Estimation of stature and body weight from static and dynamic footprints – Forensic implications and validity of non-colouring cream method: done by Petra Svabova, Susana Caplova, Radoslav Benus et.al., (2021): In this study, the metric properties of dynamic footprints were analysed using non-colouring method in relation with body parameters and compared with static footprint measurements. The samples were collected from the 65 female and 68 males (Measurement of body weight and stature). The result showed that the width of the standing footprint is larger than the width of the walking footprint, the higher correlation with stature was observed in case of right footprint in both sex groups. The width of ball exhibited the lowest correlation with stature.
8. Estimation of stature from foot length in male indigenous population of Assam Region: done by Trishna Priya Devi, Praveen Kumar et.al., (2021): The aim of this study was to determine that the estimation of stature from feet dimensions may play an important role in the identification process of a human. This study focused on the measurements of feet dimension in indigenous population groups found in the North-East Indian Region. This paper emphasized the study of a total of 200 male bodies aged between 18 to 65. The result of the analysis indicated that the foot length measurements can be successfully used by police agencies, forensic experts, and forensic anthropologists for stature

- estimation. These formulae are only applicable to the male indigenous population of Assam because of ancestry, gene, and habitat factors such as weather, calorie intake, etc.,
9. Footprint characteristics which make them unique from the forensic perspective: done by Prasansha Singla (2020): This study aimed to analyse the unique and individual characteristics of footprints of Haryanvi's - North India, from a forensic perspective. 500 samples of male and female were collected including the detailed morphological features of footprints, features of toe, features of humps, phalanges mark, creases mark. These marks were used to identify the individual. North Indian Gujjars population showed six types of humps; the frequency of three humps was the highest and one and zero hump had the least frequency. In the Thai population, study showed the five types of humps in that the frequency of three humps was the highest and five humps are the least frequent in population.
 10. Examination and Interpretation of Bare Footprints in Forensic Investigation: done by Wesley Vernon and Sarah Reel et.al., (2020): This review study attempted to examine and interpret the interest in the use of bare footprints in forensic investigations. It is only in recent times that this field has become more established through research and subsequent practice. The work of footprint examiner is to analyze, compare and evaluate footprint evidence that has been linked to a crime scene, in the form of either bare, socked, or insole foot marks. For this study they used different type of methods to compare the foot prints such as OCM, Gunn, Reel. In this review the focus was on the three-dimensional footprints created in the soft substrates such as sand or mud. It concluded that protocols developed for footprint examination and had identified the underpinning research validating these methods. Although footprint examiners were able to provide valuable assistance to crime scene investigations, they would approach each case with caution.
 11. Foot structure and their correlations with body height: done by Rodrigo Schroll Astolfi, Rayanne Carneiro Torres do Novaes et.al., (2020): Generally, studies on the relation between body height and measure of bones require access to long bones, which are not always available. In this study, samples were evaluated (138 ankle MRI and X-ray scans) and comparison was done for the measurements of four structures (the talus, distal tibia, second metatarsal and Achilles tendon) with body height. The result of this showed that a sex difference was observed - all three bone structures had a weak correlation with height in female, in male length of the talus had a moderate correlation with height, and the length of the second metatarsal had a low correlation. The sex difference observed in the proportions of the forefoot and hindfoot that correlated with body height might explain some of the differences in foot biomechanics between male and female.
 12. Bare footprint metric analysis methods for comparison and identification in forensic examination: done by Richa Mukhra, Kewal Krishan and Tanuj Kanchan (2018): This was a review study done for the comparison between different methods of analysis of bare footprints. The analysis of bare footprints has been used to offer a wide range of knowledge about different print patterns, different methods and indices that are being used to evaluate footprints is not only of prime importance in forensic examination but also help in clinical examinations and elucidation of various podiatric disorders. Amongst a number of methods that are used for the footprint analysis such as the Gunn's method, Overlay method, Robbins method etc., the Reel's method was found to be the most widely used technique for the evaluation and comparison of the footprint evidence.
 13. Identification of sex from footprint dimensions using machine learning: a study on population of Punjab in Pakistan: done by Muhammed Awais, Faizana Naeem, Nouman Rasool et.al., (2018): The present study aimed at the identification of sex using footprint features from the population of Punjab,

Pakistan. Footprint samples were collected from 280 volunteers (142 males and 138 females) from all over Punjab (age range 18-50 years). Different classification algorithms, i.e., J48, Random Tree, Random Forest, REP Tree, and Naïve Bayes have been used for the classification of sex. The results obtained from the Naïve Bayes algorithm found to be more accurate in predicting sex compared to the other algorithms. The percentage accuracy of establishing sex using ball breadth index, heel breadth index, and the toe length is 87.8% with the help of Naïve Bayes algorithm, which is quite significant for use, the results were better by using left footprint parameters.

14. Identification of footprint for crime scene analysis: done by Riya Porel, Sharanya Mazumdar et.al., (2017): The aim of this study was to collect the footprint present in the crime scene with the proper guidance and convert it to the data base for the criminal identification. Gradient mask and Canny edge detected system were used to identifies the left and right foot print. The foot measurements are important in forensic field as they can be used as body height predictors for an individual. Result of this study showed that determination of personal identity is the first and the most important step in forensic investigations and medico legal practices.
15. Individualizing characteristics of footprints in Malaysian Malays for person identification from a forensic perspective: done by Nataraja Moorthy and Siti Fatimah Binti Sulaiman (2014): The study aimed to analyze and describe the individual characteristics of footprints of Malaysian Malays from a forensic perspective in a sample of 400 adult (200 males and 200 females). Various features of toes, humps in the toe line, phalange marks, flatfoot condition, pits, cracks, corns, etc., were investigated. The sequence was found to be different from the sequence observed fin the north Indian population. Two humps were found most often in males footprints followed by three and zero hump was found to be the least frequent. While in female footprints, three humps were most often followed by two humps and zero humps was found to be the least frequent.

Methodology:

The main Aim of this study about the comparison of the both the human footprint to determine gender. this study conducted based on four objectives: To analyse the right and left footprints, To determine if there are any similarities between the prints, To estimate the degree of similarity between the prints, To determine gender based on the similarities between both footprints' dimensions. For the purpose of taking the measurements of the samples, Reel method was used. This method consists of seven measurements. the five lines from the heel to the tip of the phalanges, Heal Breath and Ball breath. This method has been adopted by practitioners and bare footprint researchers as the best practice for evaluating two-dimensional bare footprints for research purposes or criminal case work. All the 100 collected samples are measured on the basis of Reel Method.

Then, the measurements data were noted in the Microsoft excel, and analysis was done using SPSS software version 29. In that correlation analysis was done by the T-test and Percentile analysis are done using Weighted Average and Tukey's Hinges method.

Need and significance

Footprint evidence is a source of physical evidence to identify the suspect in a criminal investigation. Mainly the foot impressions are used to prove the presence of a person at the scene of a crime, and thus could be help to identify their role in the crime.

Previous studies that have been done using footprints includes estimation of stature by length and width of footprints, identification of gender from footprints and estimation of bodyweight and height from footprints, analysis of footprint pattern and also analysis of humps and phalange marks of footprints. But there are no studies for comparison of right and left footprints by measuring the dimension for both footprint and analyzing if there are any similarities between the right and left footprints of same person. This study primarily focuses on the dimension of footprints. It aims to determine if the dimension of any one footprint that is found at the crime scene can be compared with the dimension of suspect footprint to find out the individuals. It also seeks to compare the footprint of both the genders and identify which gender have maximum similarities in their footprint dimension. Further this research technique could be applied in the identification of criminal through footprints during the crime scene investigation and also can be used to point the individuals who were involved in the crime scene by analyzing the footprints of the suspects.

Analysis of data:

This chapter provides a detailed of the result of the study. After the analysis of the primary data with the help of SPSS version 29 (Statistical Package for Social Sciences), the derived results are presented in this chapter in the form of tables. The sample size of the research is 100, comprising of 50 male and 50 female. Footprints of the people were collected on a A4 sheet. Primary analysis was done manually with the measuring scale, and all raw data was analysed with the help of SPSS software.

The comparison of both left and right footprints of a person is done using T-test analysis method. All the Right samples are given as one variable such as Right thumb, Right Index, Right Middle, Right Ring, Right Little, Right Ball, Right Heal and likewise all the Left samples are given as another variable such as Left Thumb, Left Index, Left Middle, Left Ring, Left Little, Left Ball and Left Heal.

Overall sample correlation analysis:

Table 1: Overall Correlation Analysis

Overall Sample		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	Right Thumb & Left Thumb	100	.982	<.001	<.001
Pair 2	Right Index & Left Index	100	.986	<.001	<.001
Pair 3	Right Middle & Left Middle	100	.983	<.001	<.001
Pair 4	Right Ring & Left Ring	100	.979	<.001	<.001
Pair 5	Right Little & Left Little	100	.982	<.001	<.001
Pair 6	Right Ball & Left Ball	100	.947	<.001	<.001
Pair 7	Right Heal & Left Heal	100	.892	<.001	<.001

All the left and right footprints dimensions correlated each other at approximately 0.9.

Female sample correlation analysis:

Table 2: Female sample correlation analysis

Female Sample		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	Right Thumb & Left Thumb	50	.943	<.001	<.001

Pair 2	Right Index & Left Index	50	.961	<.001	<.001
Pair 3	Right Middle & Left Middle	50	.944	<.001	<.001
Pair 4	Right Ring & Left Ring	50	.953	<.001	<.001
Pair 5	Right Little & Left Little	50	.952	<.001	<.001
Pair 6	Right Ball & Left Ball	50	.945	<.001	<.001
Pair 7	Right Heal & Left Heal	50	.842	<.001	<.001

For female footprint dimensions correlation is 0.94 for thumb, middle and ball and 0.96 for index, ring and little and 0.84 for heal.

Male sample correlation analysis:

Table 3: Male sample correlation analysis

Male Samples		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	Right Thumb & Left Thumb	50	.970	<.001	<.001
Pair 2	Right Index & Left Index	50	.973	<.001	<.001
Pair 3	Right Middle & Left Middle	50	.970	<.001	<.001
Pair 4	Right Ring & Left Ring	50	.961	<.001	<.001
Pair 5	Right Little & Left Little	50	.968	<.001	<.001
Pair 6	Right Ball & Left Ball	50	.900	<.001	<.001
Pair 7	Right Heal & Left Heal	50	.800	<.001	<.001

Male footprint dimension correlation rate is approximate 0.97 for thumb, index and middle and 0.95 for ring and little, 0.9 for ball, and 0.8 for heal.

Inference: Male footprint correlation rate is higher than the female so we can easily identify the gender based on the correlation rate. While Comparing of both male and female footprint dimension correlation rate of thumb, index, middle, ring and little length measurements correlation rate of male is higher than the female. But in the ball breadth and heal breadth correlation rate of female is higher than the male.

Percentage analysis of footprint:

Table 4: Overall footprint percentile analysis:

Over all samples		Percentiles		
		25	50	75
Weighted Average	Right Thumb	22.425	23.250	24.750
	Left Thumb	22.225	23.300	24.850
	Right Index	21.925	23.250	24.875
	Left Index	21.900	23.300	24.875
	Right Middle	21.200	22.200	23.975
	Left Middle	21.100	22.200	24.100
	right ring	20.100	21.100	22.775
	left ring	20.000	21.100	22.900
	Right Little	18.700	19.450	21.150
	Left Little	18.425	19.500	21.200

	Right Ball	8.325	8.850	9.475
	Left Ball	8.400	8.900	9.400
	Right Heel	4.525	4.850	5.300
	Left Heel	4.525	4.900	5.300
Tukey's Hinges	right thumb	22.450	23.250	24.700
	Left Thumb	22.250	23.300	24.800
	Right Index	21.950	23.250	24.850
	Left Index	21.900	23.300	24.850
	Right Middle	21.200	22.200	23.950
	Left Middle	21.100	22.200	24.100
	right ring	20.100	21.100	22.750
	left ring	20.000	21.100	22.900
	Right Little	18.700	19.450	21.100
	Left Little	18.450	19.500	21.200
	Right Ball	8.350	8.850	9.450
	Left Ball	8.400	8.900	9.400
	Right Heel	4.550	4.850	5.300
	Left Heel	4.550	4.900	5.300

Table 5: Female sample percentile analysis:

Female samples		Percentiles		
		25	50	75
Weighted Average	Right Thumb	21.775	22.450	23.100
	Left Thumb	21.800	22.250	23.000
	Right Index	21.400	21.950	22.900
	Left Index	21.400	21.900	22.900
	Right Middle	20.575	21.200	22.100
	Left Middle	20.675	21.150	21.925
	Right Ring	19.500	20.100	20.825
	Left Ring	19.500	20.000	20.825
	Right Little	17.975	18.700	19.200
	Left Little	18.100	18.550	19.200
	Right Ball	8.000	8.400	8.800
	Left Ball	8.100	8.450	8.825
	Right Heel	4.300	4.600	4.800
	Left Heel	4.300	4.600	4.800
Tukey's Hinges	Right Thumb	21.800	22.450	23.100
	Left Thumb	21.800	22.250	23.000
	Right Index	21.400	21.950	22.900

	Left Index	21.400	21.900	22.900
	Right Middle	20.600	21.200	22.100
	Left Middle	20.700	21.150	21.900
	Right Ring	19.500	20.100	20.800
	Left Ring	19.500	20.000	20.800
	Right Little	18.000	18.700	19.200
	Left Little	18.100	18.550	19.200
	Right Ball	8.000	8.400	8.800
	Left Ball	8.100	8.450	8.800
	Right Heel	4.300	4.600	4.800
	Left Heel	4.300	4.600	4.800

Table 6: Male samples percentile analysis:

Male sample		Percentiles		
		25	50	75
Weighted Average	Right thumb	23.775	24.700	25.825
	Left Thumb	23.800	24.800	25.825
	Right Index	23.775	24.850	25.900
	Left Index	23.775	24.850	25.700
	Right Middle	22.975	24.100	25.125
	Left Middle	22.900	23.950	24.925
	right ring	21.700	22.650	23.650
	left ring	21.600	22.900	23.600
	Right Little	19.975	21.000	21.825
	Left Little	20.175	21.150	21.675
	Right Ball	8.900	9.300	9.825
	Left Ball	9.075	9.400	9.700
	Right Heel	4.975	5.250	5.500
	Left Heel	5.000	5.300	5.500
Tukey's Hinges	Right thumb	23.800	24.700	25.800
	Left Thumb	23.800	24.800	25.800
	Right Index	23.800	24.850	25.900
	Left Index	23.800	24.850	25.700
	Right Middle	22.700	23.950	25.100
	Left Middle	22.900	24.100	24.900
	right ring	21.700	22.650	23.600
	left ring	21.600	22.900	23.600
	Right Little	20.000	21.000	21.800

	Left Little	20.200	21.150	21.600
	Right Ball	8.900	9.300	9.800
	Left Ball	9.100	9.400	9.700
	Right Heel	5.000	5.250	5.500
	Left Heel	5.000	5.300	5.500

Result and Discussion:

Across the world many researchers have taken the initiatives for utilization of footprints in sex determination, stature estimation, height and weight analysis. Different features of foot have been used in various studies for accurate identification of sex. But such a study has been conducted to determination of gender based on the comparing the right and left footprints and correlation rate for those foot prints.

For this research study totally 100 footprints were collected from both gender male and female. The analysis was done separately for the both the genders' footprints. Also, the experimentation was conducted on a sample with a small age group 20 -25 years old people because in that time period all human will attain their full growth. However, in the present study several parameters have been used that are: length of footprints for each fingers such as thumb, index, middle, ring, little and breadth of foot by measuring heel and ball breadth.

Male footprints mean value of both foot length and breadth is higher than female footprints. Because foot length is interrelated to the stature and height of the person. So based on that while height increases foot length will also be increase, and also Genetical factor will also be influence the foot lengths and breath.

All the samples percentage analysis also done for this study at the 3 types percentage level that are 25%, 50%, 75%. In overall sample analysis 25% of peoples thumb, Index, Middle, Ring and little fingers length measurements of right foot value is higher than the Thumb, Index, Middle, Ring and little finger length measurements of left foot. But in the Breadth of footprint of Left Ball breadth value is higher than the Right Ball breadth. At 50% of people in all length & breadth values of left foot value is higher than the all length & breadth value of right foot.

75% of people Index length of both right and left measurements are same, and Heel breadth value of both right and left value also same. But in Thumb, middle, ring, Little and Ball breadth of left foot length is higher than the Right foot length.

The percentage analysis of footprint measurements was done separately for both the genders. In the female footprints right thumb measurements 32% of people have 21.775 and 34% of have 22.450 and remaining 34% of people have 23.100, same analysis was done for the Left Thumb also 32% of people have 21.800, 34% of people have 22.250 and remaining 34% of people have 23.000 while comparing with both the right and Left Thumb of female foots 0.025,0.200 and 0.100 differences are noted.

For the Index of both right and left foot prints 32% people of both right and left prints measurements are 22.400 and 34% people of have 22.900 both right and left side of footprints. Remaining 34% people measurements were noted with minute differences in the 0.050 level. Middle finger measurements 32% of people left side value is higher at 0.100 level and 34% people have 0.050 higher in right & 0.075 of value is higher in left.

For Ring and Heel breadth of female footprints all the values are same for all the percentage level. For little finger of female 32% of left foot value is higher than the right foot at 0.125 and 34% of people have right side value is higher than the left. Finally Right Ball, and Left Ball values are noted in the 0.700, 0.050 and 0.025 with minute differences.

In the male footprints Left Thumb value is higher than the right thumb at the 0.025 and 0.100 level the last 34% of people both the right and Left Thumb value is same. In the index measurements both the right and left value are same in the 32% and 33% and remaining 35% right and left values are differed at the 0.100 value. In middle finger right foot measurements higher than the left foot measurements these measurements are differed in 0.075, 0.050 and 0.075. Ring finger of male footprint measurements right ring value is higher at the value of 0.100 and 0.050 at the 32% and 35% and 33% of peoples left ring value is higher than the right ring at the 0.250. little finger of male Left Little measurements is higher than the Right Little in the 32% and 33% in the 35% of people right is higher than the left.

In the ball breadth and heel breadth of male footprints left side is higher than the right fingers at the 32% and 33% but in the 35% of peoples ball breadth of right is higher than the Left Ball breadth, In heel breadth 35% of people have same right and left measurements.

In the above analysis male footprint length is higher than the female so all the male samples footprint lengths that means from posterior heel point to the phalanges that measurements are posterior point to thumb, posterior point to index, posterior point to middle, posterior point to ring and posterior point to little so these measurements correlation rate is higher in male than the female. It was detailed showed in the above graphical representation.

In the breadth of the footprints female footprints breadth correlation rate is higher than the male, totally two breadth measurements are taken for this study one is ball breadth and another one is heel breadth. So, this breadth correlation rate is higher in female than the male. In the male samples both footprints breadth is asymmetrical but, in the female, both footprints breadth is symmetric.

Conclusion:

The conclusion of this study by comparing both left and right footprints of the persons footprint dimension to determine the gender. Further this study can be used in the investigation process if any one footprint was found at the crime, we cannot say it is difficult to find a person's gender by finding the dimension of another footprints. This analysis method is can only be apply in the full footprint identification, it cannot be applied in partial footprint it cannot be apply. It cannot be applied in the smaller age group because growing rate will affect the footprint measurements. In maximum number of people Index length of both right and left measurements are same, and Heel breadth value of both right and left value also same. But in Thumb, middle, ring, Little and Ball breadth of left foot length is higher than the Right foot length. And also, in gender-based analysis, Male footprints mean value of both foot length and breadth is higher than female footprints. Because foot length is interrelated to the stature and height of the person. So based on that while height increases foot length will also be increase, and also Genetical factor will also be influence the foot lengths and breath. It also seeks to compare the footprint of both the genders and identify which gender have maximum similarities in their footprint dimension. Further this research technique could be applied in the identification of criminal through footprints during the crime scene investigation and also can be used to point the individuals who were involved in the crime scene by analyzing the footprints of the suspects.

Limitations:

1. Most of the persons were unwilling to give their footprints due to various reasons.
2. Obtaining proper footprints was a difficult task as most of the prints were smudged and patterns were not clearly visible.

3. For most of the individuals, print of the toes were not clear especially the little finger was not fixed so it was very difficult to take measurements.
4. This analysis method is can only be apply in the full footprint identification, it cannot be applied in partial footprint it cannot be apply.
5. It cannot be applied in the smaller age group because growing rate will affect the footprint measurements.
6. Correlation rate provides the probability measurements in identification of the gender.
7. This method was available for stature estimation for gender determination reel method of footprint identification found as corroborative evidence.

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