Estimation of Gender from Footwear Impression in the Haryana Population

Dimple[1], Priyanka Verma[2], Shalini[3]

How to cite this article:

Dimple, Priyanka Verma, Shalini. Estimation of gender from footwear impression in the Haryana population. Indian J Forensic Med Pathol.2024;17(4): 259-263.

Abstract

During crime scene inspection, footwear impressions (shoe prints) are one of the most common pieces of evidence. It can establish the facts of the absence and presence of an individual at the scene, as well as the linkage of minute traces of the soil, dust, dirt, or any such material to the crime scene and the surroundings. In this study, the right-leg shoe prints from 100 participants (59 females and 41 males) of the Haryana population within the range of 18 to 50 years were collected. The parameters selected were shoe length, shoe breadth shoe size along with manufacturing marks (if any), wear and tear pattern, etc. Based upon the statistical analysis, this study provides us with information that shoe size and shoe breadth can be considered a few important parameters to differentiate between male and female footwear impressions.

Therefore, this study could be used as a method for the gender determination of an individual from the available shoe print present at a crime scene and can provide a more accurate link with the suspect.

Keyword: Crime Scene Investigators; Footwear Impression; Sex Determination; Shoe Size; Shoe Breadth; Shoe Length.

INTRODUCTION

The complexity of forensic investigation, emphasizes that crime scene is diverse due to various factors such as location, size and type of crime.[6] It highlights the dynamic and non-mechanical nature of crime scene investigation, focusing on the need for an active approach from investigators.[11]

Author's Credentials: [1]*M.Sc. Student,* [2]*Associate Professor, Department of Forensic Science, Chandigarh University, Mohali 140413, Punjab, India,* [3]*M.Sc. Student, Shree Guru Gobind Singh Tricentenary, University, Gurugram 122505, Haryana, India.*

Corresponding Author: *Priyanka Verma,* *Associate Professor, Department of Forensic Science, Chandigarh University, Mohali 140413, Punjab, India.*

Email: *priyanka.pharma@cumail.in*

Received on: *26-06-2024*

Accepted on: *12-09-2024*

The scientific investigation of a crime scene is based on scientific techniques, including Locard's principle of exchange and forensic strategies for examining physical evidence. The paper underlines the importance of considering every factor in the investigation, constantly evaluating and changing the defined area as necessary.[4,5,10] The importance of impression evidence lies in providing crucial links between the crime scene and the perpetrator.[1] The paper emphasizes the significance of footwear impressions in particular, as they can serve as a vital forensic link to suspects. However, footwear prints are often overlooked or undervalued in the legal system due to difficulties in locating and recovering them.[3] It details the process of carefully identifying the footwear from various angles, noting down its style, type, size, color, condition and signs of wear. The focal point instrument is explained as a tool used to describe wear on the sole of the shoe for comparison. The analysis of inner impressions

and other related evidence such as trace evidence to associate suspects with footwear is also part of identification.[8,9]

The paper signifies footwear marks in forensic investigations, particularly in determining the sex and stature of an individual from the random footwear impressions encountered on simulated crime scenes. It describes the different types of footwear, materials usedand the joining methods for soles and uppers. The paper also highlights the challenges associated with the deterioration of footwear marks over time, emphasizing the importance of timely recovery and comparison of footwear.[2] Additionally, it discusses the ancient art of tracking gait patterns and the decline of this practice due to urbanization. The study further explores the morphological aspects of human feet and the reliability of sex determination from skeletal remains, particularly through anthropometry and the analysis of various bones. Furthermore, it emphasizes the crucial role of individual identification in forensic investigations and highlights the lack of systematic studies for the determination of sex from footwear measurements of North Indians.

METHODS

Sample and Sample Size

In the present study, the data has been collected from individuals from different districts of Haryana. The study includes a total of 100 participants (59 females and 41 males) with age ranges between 18 to 50 years in males and 18 to 60 years in females. The collected individuals' samples were selected randomly from different socio-economic groups.

The shoe prints of the right leg from every individual were collected to study the length and breadth of the shoes. The size of the shoe was also included as a parameter in many cases shoe size is a corroborative parameter for the identification.

Inclusion Criteria	Exclusion Criteria
Participants are free from any orthopedic problems	Without consent, participants were not included.
Both male and female participants were included	Participants above 60 years were not included.
People inthe age group 18-60 were included	Participants below 18 years were not included

Collection methodology

The shoe prints were collected on an A-4 size plain white sheet to achieve clean and proper

prints. The right shoes of all the participants were made to dip in water poured on the plane surface. They were then instructed to walk normally on the plane surface for a few seconds. At last, all the individuals were instructed to place their right leg shoes on the plain white sheet that was kept on their way while they walked. With the help of a transparent scale of length 30 centimeters, the length and breadth of all the collected show prints were measured.

Sample Analysis

At the scene of the crime, the observed shoe print can be of any category either formal shoes, chappals, sandals, or sports shoes. But to eliminate the hindrances in the research and achieve accuracy in the results of sex estimation a specific category of shoes i.e. Sports shoes were considered because a majority of the population prefers to wear sports shoes only. The parameters of shoe measurement were:

1. **Shoe Length [SL]:** It is the total length between the rearmost and foremost prominent shoe points.

2. **Shoe Breadth [SB]:** It is the massive sideward length between the furthermost prominent shoe points on the foot crest zone.

The author herself took the measurements and we recorded the data in centimeters. The analysis of the collected samples was done by multivariate and univariate techniques.

In males, the values obtained for shoe length varied from 26 cm to 31 cm, the shoe breadth was found in the range of 8 cm to 12 cm and shoe size was between 5 to 13 in number.

Table 1: Descriptive statistics of measured characteristics in males

Characteristics	Mean Value	S. D
Shoe Length	27.93	1.72
Shoe breadth	10.07	1.04
Shoe Size	10.25	2.40

In females, the values obtained for shoe length varied from 22 cm to 28 cm, the shoe breadth was found in the range of 7.8 cm to 11.2 cm and shoe size was between 4 to 10 in number.

Table 2: Descriptive statistics of measured characteristics in females

Characteristics	Mean value	S.D
Shoe length	25.12711864	1.548617905
Shoe breadth	9.306779661	0.792391493
Shoe size	6	1.380279832

Fig. 1: Shoe print length analysis

Fig. 2: Shoe print breadth analysis

Table 3: Descriptive statistics of measured characteristics in both

Characteristics	Total Value	S.D
Shoe Length	26.279	2.112746071
Shoe breadth	9.623	0.9777168829
Shoe size	7.745	2.806463499

RESULTS & DISCUSSION

In the study, a total of 100 samples were collected including males and females as participants for studying the class characteristics of their footwear impressions. Characteristics like shoe length, shoe breadth and shoe size were considered for this study to estimate the sex of an individual from their footwear impressions up to an extent. As many times in forensic cases, investigators encounter footwear impressions, that may or may not be clear or complete. In such cases, it becomes quite difficult for the investigator to ascertain the sex of an individual. Though several researches have been done on barefoot impressions, however, more data is needed to establish such facts. The results obtained during this study were relatively satisfactory and promising in the determination of sex from footwear impressions of an individual. The null hypothesis "determination of sex from footwear impression is not possible" was rejected based on the statistical results obtained.

The statistical data of shoe size (SS) was found highly precise compared to shoe length for the determination of sex through footwear impression examination. Firstly, the shoe size was able to determine the gender of an individual from the footwear markings as well as to differentiate with the opposite gender.

Studies revealed that shoe breadth (SB) was considered more accurate than shoe length in the determination of sex from footwear impressions as evident from the statistical analysis. During the analysis of comparing shoe length and shoe breadth

for male and female participants, the probability value obtained was highly significant showing a clear demarcation between the male and female footwear impressions. Also, the shoe breadth on the other hand strongly supported the gender determination in all the selected samples.

Therefore, it was more evident from the above analysis and interpretation of the results that shoe size and shoe breadth contain more data to differentiate between male and female footwear impressions.

With certain limitations like poor impressions, incomplete impressions, oversized footwear and impressions of children may not provide the desired results. These further need to be researched and analyzed.

In this study, 90.0% of cross-validated grouped cases were correctly classified. The most dimorphic single parameter was the foot length providing cross-validated sex-predicting accuracy rates of 96.6% and 94.0% for the right and left foot, respectively. The study reveals that foot and footprint measurements can be used effectively to classify sex with a high degree of accuracy among the Sinhalese population in Sri Lanka.[7, 11-13]

Future Scope of the Research Work

Footwear impressions have great potential value at the scene of a crime for the identification of criminals, linkage of the crime with the crime scene and the criminal. However, in many cases, complete footwear impression is absent where it becomes difficult for the investigator & forensic expert to identify the individual and its linkage with the crime. Also, it becomes necessary in certain cases to determine the sex of an individual from the footwear impression in cases where we have either male suspect or female suspects. In sch cases, this study will definitely be fruitful for the investigator to evaluate appropriate stature of an individual along with the determination of sex. This study gives a further scope for the researchers to use several other methods like gait pattern, FL and FB for proper determination of sex with the aid of footwear impression.

CASE STUDIES

Footwear impressions have played a crucial role in solving numerous crime cases. Here are a few notable examples:

The Murder of Jill Dando (1999)

Case Summary: Jill Dando, a British television presenter, was murdered outside her home in London.

Footwear Evidence: Investigators found a partial shoe print at the crime scene that matched with the unique tread pattern of a specific type of shoe. This helped link Barry George, the suspect, to the scene. Although George was initially convicted, his conviction was later overturned on appeal due to insufficient evidence, including doubts about the footwear impression's reliability.

The BTK Killer (Dennis Rader)

Case Summary: Dennis Rader, known as the BTK (Bind, Torture, Kill) killer, terrorized Wichita, Kansas, for decades.

Footwear Evidence: Footwear impressions found at some of the crime scenes matched the shoes owned by Rader. These impressions, along with other forensic evidence and his own admissions, were crucial in securing his conviction.

The Rillington Place Murders (1940s-1950s)

Case Summary: John Christie, a serial killer in London, murdered several women, including his wife.

Footwear Evidence: Footwear impressions in the garden of Christie's home at 10 Rillington Place helped to corroborate the locations where he had buried his victims, providing critical evidence in the case.

The Clutter Family Murders (1959)

Case Summary: The brutal murder of four members of the Clutter family in Kansas was later detailed in Truman Capote's "In Cold Blood".

Footwear Evidence: Footwear impressions found at the crime scene matched the boots worn by Perry Smith, one of the murderers. This evidence was pivotal in linking Smith and his accomplice, Richard Hickock, to the crime.

The Soham Murders (2002)

Case Summary: The murders of two ten-year-old girls, Holly Wells and Jessica Chapman, in Soham, England.

Footwear Evidence: Footwear impressions matching the boots of Ian Huntley, the school caretaker, were found at the scene where the bodies were discovered. This, along with other forensic evidence, led to Huntley's conviction.

Dimple, Priyanka Verma, Shalini. Estimation of gender from footwear impression in the Haryana population

263

REFERENCES

1. *Adair T.* Basic Skills for Scene Processing: Impression Evidence. In Practical Crime Scene Processing and Investigation, Third Edition 2018 Sep 20 (pp. 233-253). CRC Press.

2. *Budka M, Bennett MR, Reynolds SC, Barefoot S, Reel S, Reidy S, Walker J.* Sexing white 2D footprints using convolutional neural networks. Plos one. 2021 Aug 18;16(8):e0255630.

3. *Daniel O, Levi A, Pertsev R, Issan Y, Pasternak Z, Cohen A.* The Next Step–a semi-automatic coding and comparison system for forensic footwear impressions. Forensic Science International. 2022 Aug 1;337:111378.

4. *Kostenko, D. (2020).* An investigator is not a friend of a forensic investigator?. НаучныйКомпонент, (2), 74-84. doi: 10.51980/2686-939x_2020_2_74

5. *Mishra A, Nagda B.* Study of water quality in Udaipur Region, India. Asian Journal of Water, Environment and Pollution. 2020 Jan 1;17(1):51-7.

6. *Millen, P. (2000).* Is crime scene investigation forensic science? Are crime scene investigators forensic scientists?. Science &Amp; Justice, 40(2), 125-126. doi: 10.1016/s1355-0306(00)71957-5

7. *Kumar A, Mishra A.* Anatomical variations in the branching pattern of human aortic arch: a cadaveric study from Nepal. Eur J Anat. 2015 Jan 1;19(1):43-7.

8. *Singh C, Rani MS, Mishra A.* Development of analytical method for detection of monocrotophos insecticide from biological matrix using lc-ms/ms. International Journal of Medical Toxicology & Legal Medicine. 2020;23(1and2):210-9.

9. *Smale AN, Speir JA.* Estimate of the random match frequency of acquired characteristics in footwear: Part I—Impressions in blood. Science & Justice. 2024 Jan 1;64(1):117-33.

10. *Wright, W., & Hirsch, C. (1987).* The Physician Assistant as Forensic Investigator. Journal of Forensic Sciences, 32(4), 12414J. doi: 10.1520/jfs12414j

11. *Mishra A, Shukla SK, Tayal I, Ashwini K, Shilekh M, Rajiv J.* Trends of Poisoning in Developing Country–A Ten-year Retrospective Study. Journal of Punjab Academy of Forensic Medicine & Toxicology. 2017;17(1) 35-39.

12. *Yadav N, Mudgal D, Mishra A, Shukla S, Malik T, Mishra V.* Harnessing fluorescent carbon quantum dots from natural resource for advancing sweat latent fingerprint recognition with machine learning algorithms for enhanced human identification. Plos one. 2024 Jan 4;19(1):e0296270.

13. *Barbaro A, Mishra A, editors.* Manual of Crime Scene Investigation. CRC Press; 2022 Oct 28.