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DETERMINATION OF STATURE FROM FOOT LENGTH WITH REFERENCE TO MALAY POPULATION

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Science (Health) in Forensic Science

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2006

CERTIFICATE PAGE

CERTIFICATE

This is to certify that the dissertation entitled

"Determination of Stature from Foot Length with Reference to Malay Population"

is the bonafide record of research work done by

Ms. Khairulmazidah Mohamed

during the period of January 2006 to April 2006

under my supervision.

Signature of supervisor: .....

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ACKNOWLEDGEMENT

In the name of The Almighty, The Most Gracious, The Most Merciful....

First of all I would like to thank God, as for Him I was managed to complete my project. I would like to thank Professor Dr Zainul Fadziruddin Zainuddin, the Dean of School of Health Sciences, Dr. Che Wan Zanariah Che Wan Ngah, Chairman of Forensic Science Programme and Associate Professor Dr. R. Kuppuswamy, the research coordinator. Also I would like to express my deepest gratitude to my research supervisor, Mr. T Nataraja Moorthy for guiding and helping me throughout the period of my research work and made it successful. Thank you for your patient, constant encouragement and guidance.

Also I would like to express my gratitude to my colleague Ms. Rina Haryani, for her continuous help and support. It is a pleasure to work as a team with you. My gratitude also goes to Ms. Sharifah Nur Hafiza and Ms. Zulaiha for helping me during the sample collection. I would like to thank all my friends for supporting me all the way until this research is completed. I am very grateful to all the persons who were involved directly and indirectly and helped to conduct this project. Only God can reciprocate what all of you gave to me.

Last but not least, I would like to thank my parents for their constant support. I hope that my work will be useful to the police officers and forensic investigators in Malaysia in future whenever they come across footprints in the scene of crime.

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ABSTRACT

Foot impression evidence are often found at the crime scene during the commission of offences like burglary, robbery, and even in murder cases an so on. Although this type of impression is occasionally found at the scene when compared to shoe impression evidence, criminals tend to remove their footwear while committing crime in order to avoid noise while walking, to have better grip in climbing walls, and comfortable for fast escaping. In Asian countries, in many places people tend to walk in barefoot.

A lot of information can be obtained from foot impression evidence. This evidence can be used as a positive evidence in many crime scenes. This is because of the uniqueness of footprint in terms of the ridge characteristic on the sole as well as the shape of the foot from various dimensions. The length of the foot is a valuable factor to identify the height of the person who committed the offence.

Estimation of stature from the dimensions of foot or shoeprints has considerable value in forensic investigation as to develop descriptions from evidence at the crime scene and in corroborating height estimates from witnesses. In this study, the regression equation of stature estimation from foot length is derived using the simple linear regression statistical method from 107 subjects. The population is represented Malay population from various districts and states in Malaysia. The formulae derived have been recorded.

INTRODUCTION

In all our actions we leave a mark. It happens when we are walking, driving, working, sitting on a chair or even speaking. While we carry out these tasks, our feet or shoes, clothes, hands, the tools we use and even our speech can leave unique tell-tale signs to the expert's eye. A car can leave tyre tracks, our feet leave foot impressions, and even the screwdriver used to take the lid off the paint tin leave its mark. The simple principle that Locard proposed was 'every contact leaves a trace' and in the field of marks and impressions, if we put two items together, they are likely to leave a mark on one another (Barnett and White, 1998).

Sherlock Holmes in his book 'A Study in Scarlet' said that 'there is no branch of detective science which is so important and so much neglected as the art of tracing footsteps'. In these cases there are features present that can be used to form a unique connection between suspect and scene or stolen property.

Whenever a person takes a step, whatever the surface they are walking on, they may leave footprint or footwear impression. An impression may be defined as the retention of the characteristics of an item on another object. Thus feet sink into soft surface and leave their characteristic impression. The impression left on some surfaces may not always be so obvious and can be difficult to find without the aid of some special technique. The more the number of impressions available in a crime scene, the more the availability of individual characteristics that can link the crime scene and criminal. Thus it is possible that the shoe may have one or more damage marks that may provide a significant link between a suspect's foot and impression in the scene of a crime.

When talking about foot impression evidence, one must know the anatomy of the human foot. This is important to know why the foot has a particular shape and what causes the ridges, marks and features in the foot that made the footprints unique.

The human foot combines mechanical complexity and structural strength. The ankle serves as foundation, shock absorber, and propulsion engine. The foot can sustain enormous pressure (several tons over the course of a one-mile run) and provides flexibility and resiliency.

The foot and ankle contain (1) 26 bones (one-quarter of the bones in the human body), (2) 33 joints, (3) more than 100 muscles, tendons (fibrous tissues that connect muscles to bones), and ligaments (fibrous tissues that connect bones to other bones), and (4) a network of blood vessels, nerves, skin, and soft tissues (Anatomy, 2005).

These components work together to provide the body, a support, balance, and mobility. A structural flaw or malfunction in any one part can result in the development of problems elsewhere in the body. Abnormalities in other parts of the body can lead to problems in the feet.

A network of muscles, tendons, and ligaments supports the bones and joints in the foot. There are 20 muscles in the foot that give the foot its shape by holding the bones in position and expand and contract to impart movement (Anatomy, 2005).

Skin, blood vessels, and nerves give the foot its shape and durability, provide cell regeneration and essential muscular nourishment, and control its varied movements.

The anatomy of the foot shows that all the muscles, skin, blood vessels, and nerves in the foot area give a specific shape and movement which provide a signal or clue during forensic investigation. The shape of foot is very important feature in characterizing a person. Even to twins, the shape of the foot would be different (Figure 1). Moreover the

ridges present in the sole of the footprint serve as an individual characteristic evidence like fingerprint.

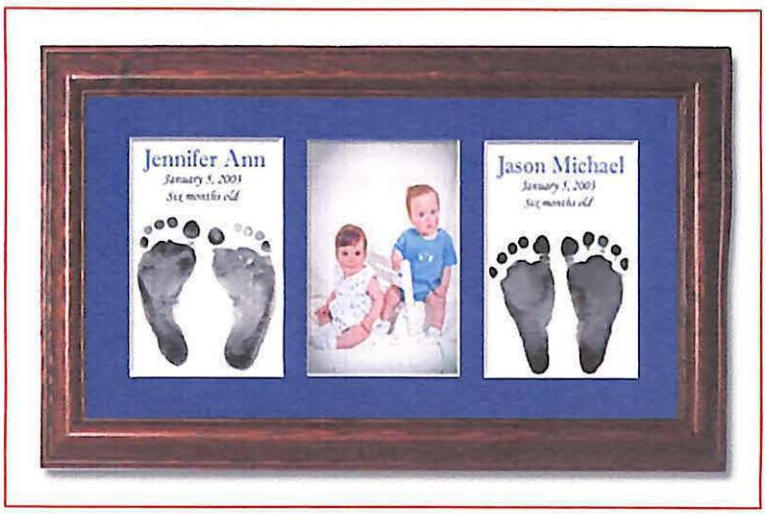

Figure 1: Footprints of twins.

Foot and footwear evidence can be found in two forms, viz. impressions and prints. The impression normally describe the three-dimensional (3D) one, left on the soft surfaces like mud, flour, beach soil and all powdery materials. The print is described as one made on a solid surfaces like concrete floor, table tops, glass plate and similar surfaces and it is two dimensional (2D) in nature. In this research project, I have chosen 2D footprints for my study collected from 107 Malay subjects.

Footprint evidence, as well latent fingerprint evidence, are classified into three categories of crime scene prints (Hilderbrand, 1995):

1. Visible Prints
2. Plastic Prints
3. Latent Prints

The Visible Prints: A visible print occurs when the foot steps into a foreign substance and is contaminated by it, and then comes in contact with a clean surface and is pressed onto that surface. This print can be visibly seen by the naked eye without any other aids.

The most common visible prints are prints left on a contrasting surface, such as a kitchen floor. A variety of substances, such as blood, grease, oil, or water will leave contrasting prints. This type of print must be photographed, prior to any other methods being used to lift. An electrostatic dust lifter can also be utilized when the evidence is on dust. I have used visible prints for my study, by applying fingerprint ink on the foot and subsequently laid on the white papers.

The Plastic Prints: Plastic prints are impressions that occur when the foot or footwear steps into a soft surface, such as deep mud, snow, wet sand, or dirt creating a three-dimensional impression. This type of impression should be photographed and then cast. These types of impressions are three-dimensional because they allow the examiner to see length, width, and depth. In future, attempts can be made to conduct a similar project by collecting these plastic prints but it is very difficult to collect the samples in these surfaces.

The Latent Prints: Latent prints are the most overlooked print and are generally found on polished and smooth surfaces. They can be developed the same way as latent fingerprints. This type of print needs a variety of powders, chemicals and even forensic light sources to make it visible in order to properly be collected. In most cases these prints should also be photographed prior to any recovery process. (Hilderbrand, 1995)

The first step of this project is the collection of known 2D footprints from 107 Malay subjects in a systematic way. There are several technique are known to record known print of the suspected shoes. Some commonly used technique to record known print are listed below:

Black inks

Black oil-base inks, such as printing inks or fingerprint inks, and gels, allow for impressions of excellent contrast and detail. In my research project, I have used this technique to record the footprints from the Malay subjects.

Water-based ink and tracing paper impressions

The use of water-based ink and tracing paper provides a quick and relatively inexpensively way of producing several test impressions.

Inkless method

A method of taking impressions without ink uses materials produced by the Identicator Corporation, Marina Del Re, CA.

Fingerprint powder and roller transport film

Produces both an excellent test impression and an excellent transparency involves the use of a photographic product known as roller transport film.

Fingerprint powder and clear adhesive

This method involves black fingerprint powder and a clear adhesive sheet and is one that provides a full presentation of the outsole of the known shoe.

Fingerprint or talcum powder with gelatin lifting products

A clear gelatin lifter combined with a powdered shoe, using the aforementioned procedure, will provide a quality impression that can be used as a transparency.

Black chart board and talcum powder impressions

Black solid-care chart board can also be used in conjunction with light colored powder.

Oil residue impressions dusted with fingerprint powder

Another method involves coating the shoe sole with a thin coat of petroleum jelly or oil and record the print.

There are many informations can be obtained from the footprint and footwear impression evidence. These include:

Identification- The identification of footwear evidence can be made by means of side by side comparison of suspect's shoes with the print or impression found at the crime scene. A sufficient number of characteristic marks will lead to a positive matching.

Linking footwear to a particular time- From the location of the shoeprint and consecutive of the shoeprint, a certain timeline can be elucidated.

Corroboration or rebuttal of alibis- Information from the location of the shoeprint, direction of the shoeprint and all other information can be used to corroborate or rebut the alibis.

Estimate or determine the shoe size- The length of the outsole is one of the factors that can be used to estimate the size of the shoes. This is a very useful issue in forensic investigation to apprehend the suspect(s).

Estimate the height of a person- A formula needs to be applied in order to estimate the height of the individual from the length of the foot found in the crime scene. Some researches have been made by the scientists to derive a formula for this technique. My research is based on this technique to derive formulae for Malay populations in Malaysia.

Crime scene linking- The shoeprint can link the suspect to the crime scene. Also can link a scene of crime with another scene of crime.

Location of impression- Location of impressions may help in the reconstruction of the crime scene as it shows the position of the perpetrator(s) at the scene of crime.

Numbers of perpetrators- The design and characteristic marks can determine the number of perpetrators involve in the offence, thus help the investigation process.

Tracking - If several consequent shoeprint are found at the crime scene, this may help the police to track down the perpetrator(s) as the person may lead to certain direction. If the

perpetrators escaped through a vehicle and there got tyre tracks, this would also aid the investigation.

Gait characteristics- If the prints are found in the form of a few consecutive footprints or shoeprints, the gait characteristic or the style of walking is used as a tool to fix the accused.

Elimination- Foot or shoeprint can also be used for elimination process. If the footprint or shoeprint found at the crime scene is not tallied with the footprint or shoeprint of the suspect, then the suspect(s) can be eliminated from the list of the suspects.

Footprints have not gained the popularity in western countries because of the relative rarity of such evidence. In Asian countries like India, Sri Lanka, China and Malaysia however, people walk barefooted inside the house and nearby. Besides, criminals will remove their footwear in order to avoid noise while walking, to have better grip in climbing walls, and comfortable for fast escaping. Moreover, the pattern of footprint in the insole of the shoe left at the crime scene may also be of interest of the forensic scientist as this also can indicate the wearer of the shoe. All these tendencies provide ample opportunity in the availability of footprints in crime scene thus can be used in crime investigation.

REVIEW OF LITERATURE

So far, a lot of studies have been made in estimation of stature from foot length as well as estimation of stature from other parts of the body. In earlier studies, two approaches have been used in prediction of stature, viz. a) expression of foot length as a percentage of stature and b) least-squares regression with stature as the dependent variable and foot length as the independent variable. In most of the cases, they used the simple linear regression when it involves only two variables. But when involves more than two variables, multiple regressions is applied.

In the mid 1800s, physical anthropologists like Topinard and Rudolf Martin developed a ratio of foot length to stature as a result of measuring numerous subjects. Pales's study in estimating the height of Paleolithic Homo sapiens used the Topinard and Martin's 15% ratio. However Pales have doubt about the 15% ratio, so he tested its validity by measuring feet. From his work, he accepted the 15% ratio, but also proposed an equation for determining stature from the right and left feet of adult males. He used the simple linear regression to arrive the equation. (Topinard, 1877; Martin, 1928; Pales, 1976 cited by Robbins, 1986)

Robbins (1986) in her study with more than 500 subjects also tested this 15% ratio and derived an equation for height estimation in US population. In her study, she also checked the correlation between the widths of the footprint to the weight of the person. As predicted, there is significant relationship between stature and foot length as well as weight and foot width.

Giles and Vallandigham (1991) in their study of height estimation from foot and shoe length of the modern young adult male and female using US Army as their subjects, was also managed to derive few formulae for stature estimation.

In Tokyo, in a study using a total of 533 males and 567 females from three different ethnic groups of the same height, body weight and width were measured, and a linear regression balance was found for different groups and sex measurement averages, differences are pronounced. Female and male from the different ethnic groups, but having the same height, showed a difference in foot lengths. According to the results obtained by the researchers, morphometric works should be made with attention to the society (Ashizawa et al., 1997 cited by Ozden H. et al., 2005).

Saxena, in a study at Nigeria using 100 male medical students in the age group between 20 and 30, collected right foot lengths for estimating the height, derived a formula, height = 67.4929 ± 3.9755 x right foot length (Saxena, 1984 cited by Ozden H. et al., 2005).

Jasuja and Manjula (1993) studied height estimations from print averages made with and without shoes. Jasuja et al. for the estimation of height when length measurement were used rather than width measurements, bare foot measurements gave better results than shoe measurements, and less standard deviation extremes were asserted in the given approximations.

In Ozden (2005) study, better results were achieved in height estimation in terms of foot length measurements than in foot width measurements. The correlation coefficient between male and female foot and shoe length with height was seen to be closer to Singh and Phookan's correlation coefficient finding, with the differences being 0.579 in Ozden's study with 0.614 in study made by Singh and Phookan for male and 0.500 in Ozden's study with 0.490 in study made by Singh and Phookan for female.

Gordon and Buikstra (1992), for the development of their linear model for height estimation from foot and shoe measurement, showed a strong relationship between the calculation model with foot and shoe length and height. In Ozden study, for males and

females, beside left and right foot lengths, other factors of importance was determined. The same definition was made for other parameters.

Smith (1997) had formed distal and proximal phalanges with metatarsal bones that may prove to be useful, when giving of results of sex differentiation from cranial and pelvic bone examinations is not. With the help of the models gained, it was noticed that determination of one's sex could be done with an 86–98% accuracy ratio. Because there may be differences between different societies in order of shoe size and people's feet size, and especially in winter both male and female may wear the same kind of footwear. It was supposed that if any kind of shoes were found on the spot, this study would lead the determination of sex.

A lot of parameters are needed for sex estimation from dimension of foot or shoe size, like mentioned in Ozden's (2005) study. So, in my research study, I used only footprint and foot outline as the means of getting the regression equation of stature estimation from foot length. However, it must be explained here that the footprints in my study reflects the two dimensional footprint evidence that might be found at the scene of crime. And the foot outline reflects the length of three dimensional foot impression evidence that might be encountered at the crime scene.

OBJECTIVE OF THE STUDY

The objective of this study includes

1. to arrive an equation for stature estimation from foot length with reference to Malay population in Malaysia.
2. to analyze whether there are any significant difference when the sex are separated and when not separated.
3. to arrive an equation for stature estimation from length of footprint, which reflects the two dimensional footprint.
4. to arrive an equation for stature estimation from length of foot outline, which reflects the three dimensional foot impression.

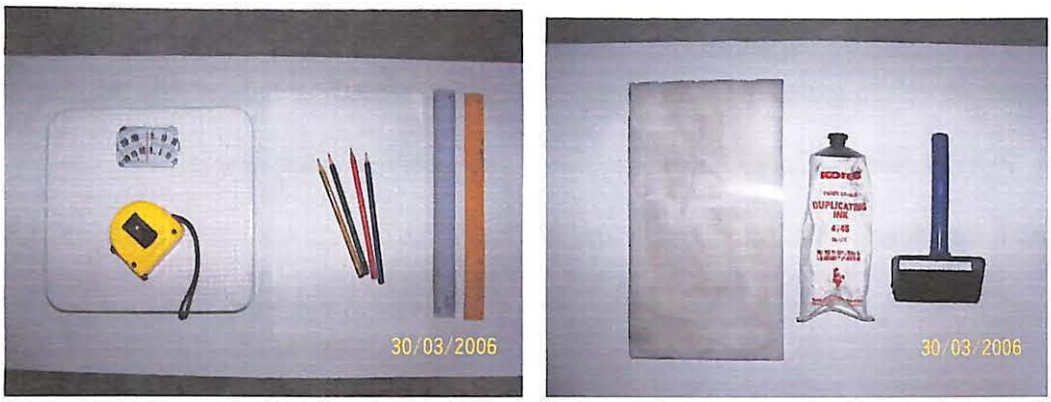

Figure 2: Materials used for collection and analysis of footprints from subjects

MATERIALS

1. Foot print kit
2. Scale
3. Pencils
4. F/P roller
5. F/P roller plate
6. F/P ink
7. F4 papers
8. Apparatus for stature measurement
9. Ruler
10. Triangle ruler
11. Protractor
12. Digital camera

Sample Collection

A few session of sample collection were conducted among Malay population from various districts and states in Malaysia. A random collection of samples from 42 male and 65 female between the age group 17 and 36 years were completed and the total number of subjects is 107. The subjects selected would represent the Malay population in Malaysia.

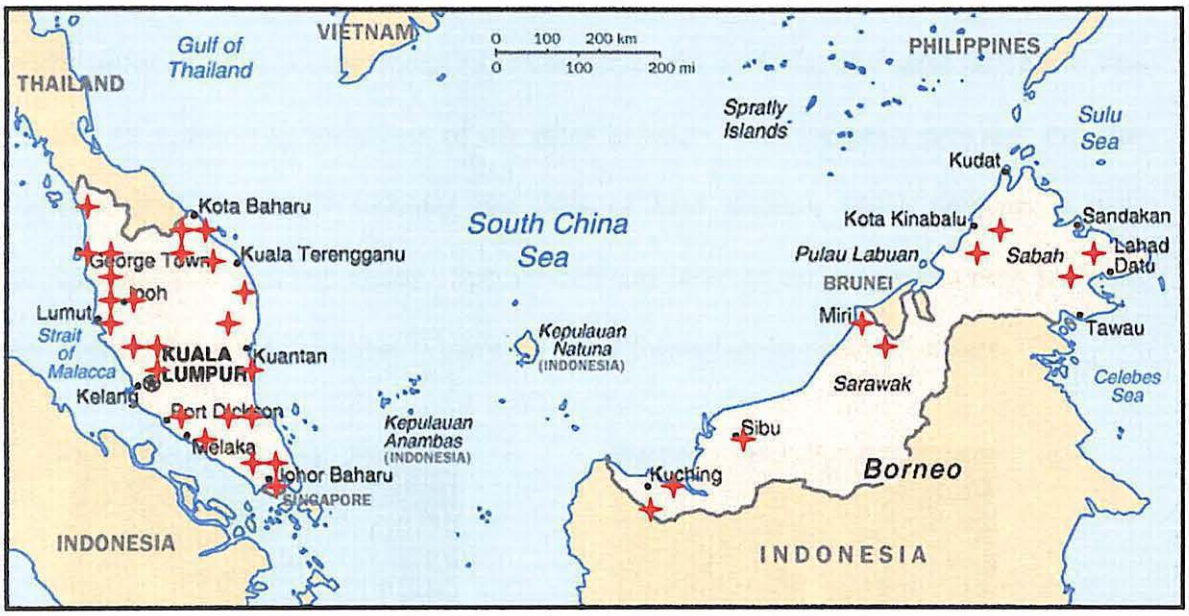

Figure 3: The distribution of subjects in Malaysia

The means of recording the footprints in this study is by using the fingerprint (F/P) ink, which is black in color. First of all, the subjects were weighed and their statures (standing height) were measured using the appropriate device. Stature of an individual is the vertical distance from floor to vertex when the individual is standing barefooted and with head in the Frankfort plane. Other information like age, sex, place of origin, names etc were also recorded. Then the subjects were asked to stand on an F4 paper which is held

on an even surface for recording the foot outline. The foot outline was drawn using a sharp-pointed pencil on that sheet of paper. The pencil was held perpendicular to the paper and is traced around the margins of the foot. After recording the outline of the foot, the same procedure was adopted to record the outline of another foot. The foot outline provides the size parameters of the fleshed bare foot and also represents the boundaries of the foot impression in soft soil, mud or any other substance that produces a three-dimensional footprint impression. Then, the subjects were asked to step on the F/P plate on which the F/P ink was applied and spread evenly using the F/P roller. Care was taken that the foot is merely covered with black ink. Then the subjects were asked to step onto a white paper and thus a clear footprint is transferred for analysis. The same procedure was applied to record the footprints of all other subjects. The footprint provides the size dimensions face actually touching the floor or hard surface, which produces a two-dimensional footprint impression. Special care was taken to make sure that both footprint and foot outline of all the subjects were collected following the same procedure.

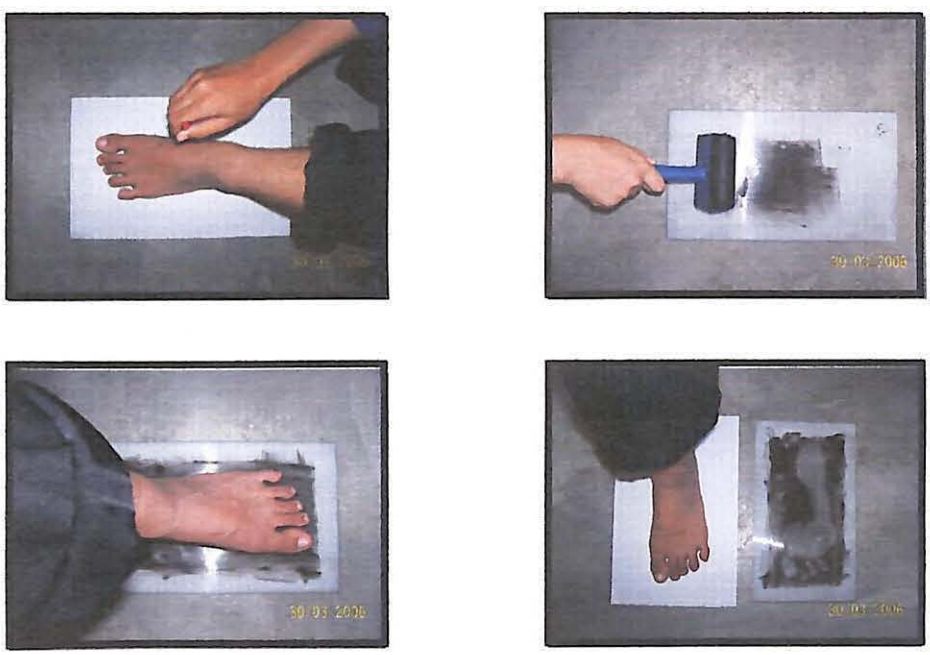

Figure 4: Collection of outline and inked 2D print

This collection procedure resulted in "standing" footprint and foot outline being obtained from the left and right foot of each subject. They are shown in Figure 5-8.

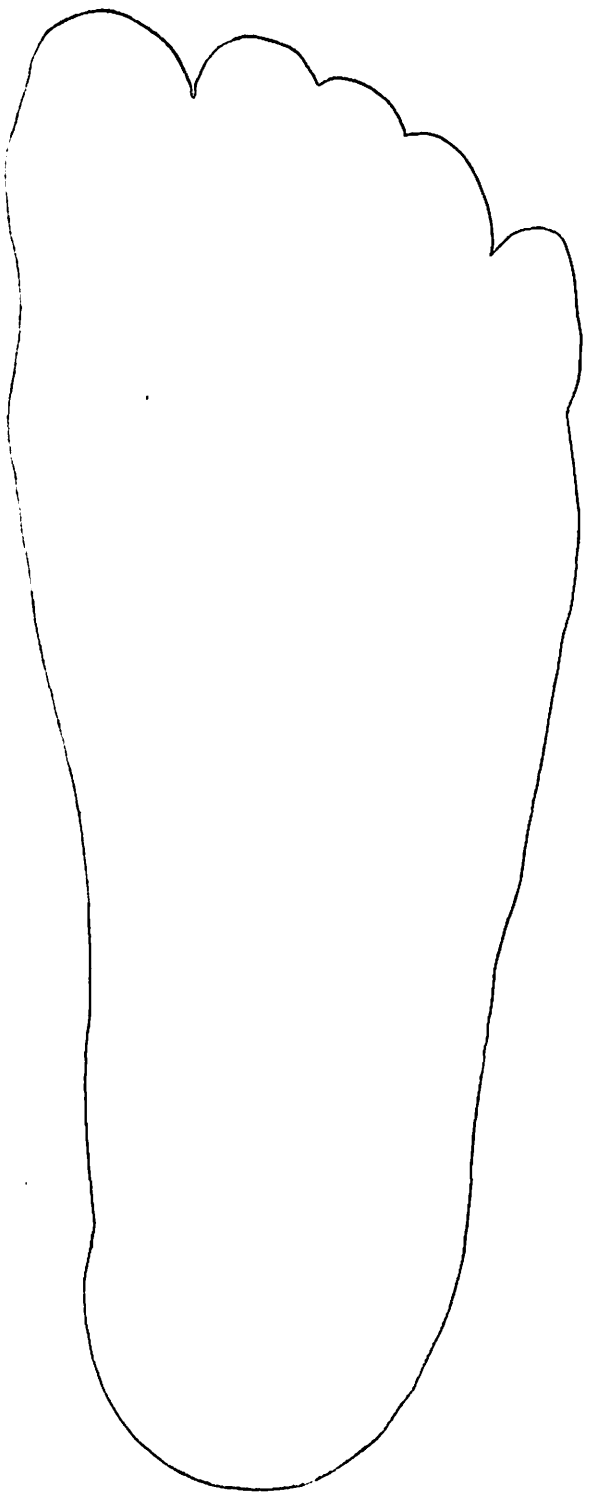

Figure 5: Right foot outline

Figure 6: Right footprint

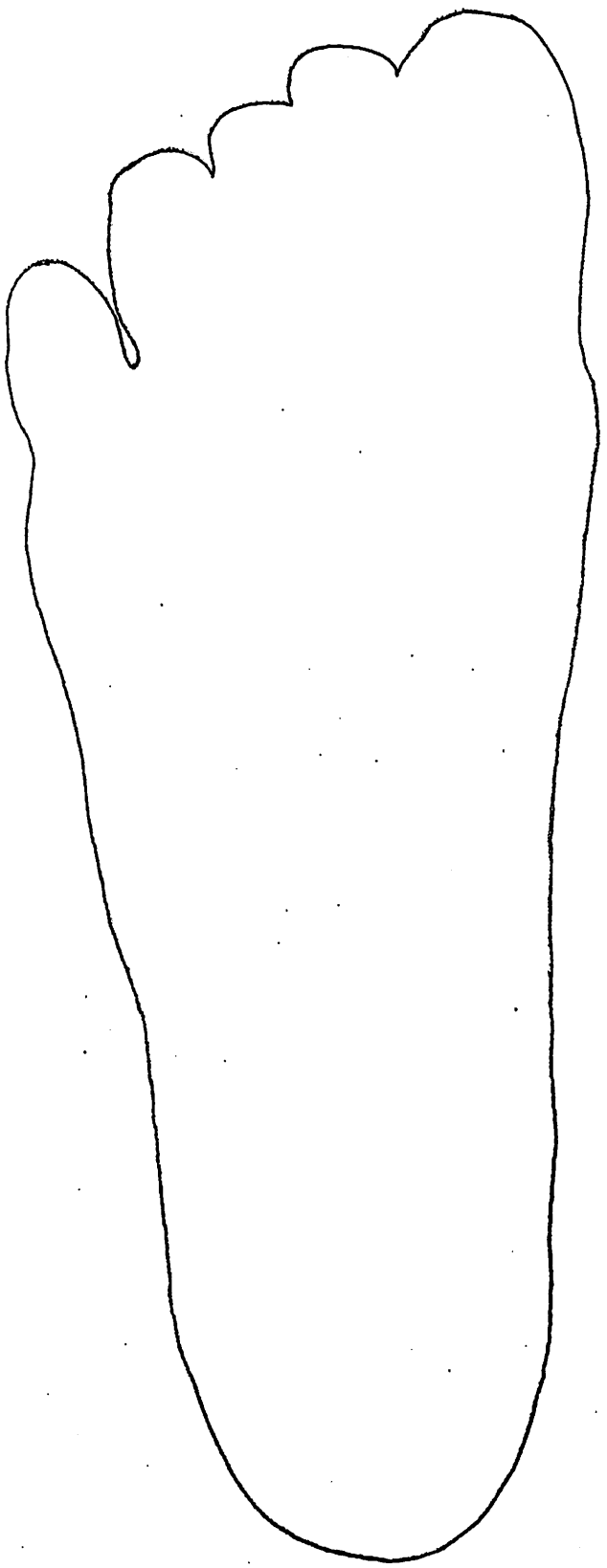

Figure 7: Left foot outline

Figure 8: Left footprint