Egyptian Journal of Forensic Sciences (2014) 4, 7–16

Contents lists available at ScienceDirect

Egyptian Journal of Forensic Sciences

journal homepage: www.ejfs.org

ORIGINAL ARTICLE

Stature estimation from footprint measurements in Indian Tamils by regression analysis

T. Nataraja Moorthy [a,*], Ahmad Mustaqqim Bin Mostapa [a], R. Boominathan [b], N. Raman [b]

[a] Forensic Science Program, University Sains Malaysia, Kubang Kerian, Kelantan, Malaysia
[b] VHNSN College, Madurai Kamaraj University, Virudhunagar, India

Received 5 June 2013; revised 22 September 2013; accepted 29 October 2013
Available online 5 December 2013

KEYWORDS

Forensic science;
Forensic anthropology;
Stature estimation;
Footprint;
Indian Tamils

Abstract Stature estimation is of particular interest to forensic scientists for its importance in human identification. Footprint is one piece of valuable physical evidence encountered at crime scenes and its identification can facilitate narrowing down the suspects and establishing the identity of the criminals. Analysis of footprints helps in estimation of an individual's stature because of the existence of the strong correlation between footprint and height. Foot impressions are still found at crime scenes, since offenders often tend to remove their footwear either to avoid noise or to gain a better grip in climbing walls, etc., while entering or exiting. In Asian countries like India, there are people who still have the habit of walking barefoot. The present study aims to estimate the stature in a sample of 2,040 bilateral footprints collected from 1,020 healthy adult male Indian Tamils, an ethnic group in Tamilnadu State, India, who consented to participate in the study and who range in age from 19 to 42 years old; this study will help to generate population-specific equations using a simple linear regression statistical method. All footprint lengths exhibit a statistically positive significant correlation with stature (p-value < 0.01) and the correlation coefficient (r) ranges from 0.546 to 0.578. The accuracy of the regression equations was verified by comparing the estimated stature with the actual stature. Regression equations derived in this research can be used to estimate stature from the complete or even partial footprints among Indian Tamils.

1. Introduction

Every part of the body is different in its own way not only within a particular body, but also from other bodies. There is also a relationship between each part of the body and the whole body. Nothing exemplifies this truth more than the relationship that various parts of the body have to the stature of an individual.[1] In this manner, an individual's footprint may represent his or her identity. Person identification using foot-

* Corresponding author. Tel.: +60 97677589/129224610 (HP); fax: +60 97657515.
E-mail address: nataraja@kb.usm.my (T. Nataraja Moorthy).
Peer review under responsibility of Forensic Medicine Authority.

Production and hosting by Elsevier

2090-536X © 2013 Production and hosting by Elsevier B.V. on behalf of Forensic Medicine Authority.
http://dx.doi.org/10.1016/j.ejfs.2013.10.002

prints is also an emerging biometric technique.[2] Footprints as valuable physical evidence available at crime scenes are used to link the crime to the perpetrator. Footprints can be collected from almost all types of crime scenes, and the possibility of their recovery at the scenes of sexual offenses and homicides is relatively more.[3] Characteristic features may provide useful clues to establishing personal identity whenever complete or partial footprints are recovered at the crime scene and that can help in including or excluding the possible presence of an individual at the scene of the crime.[4]

Examination of barefoot impressions is important, especially in Asian countries like India where the majority of the rural population walk barefoot. This is largely due to socioeconomic and climatic conditions. The partial or complete footprints can be found on rain covered surfaces; newly waxed floors; freshly cemented surfaces; moistened surfaces; in dust, mud, sand, oil, paint; and can be left in blood at the murder scenes[3,5,6] An aspect of human identification that has received scant attention from forensic anthropologists is the study of human feet[7] and the footprints[8] made by the feet. Researchers have been conducting stature estimation research using foot[9–26] and footprints[27–33] because of the existence of a strong correlation between one's stature and foot size[34] From the analysis of footprints, definitive information on many physical characteristics of the individuals who made them can be retrieved. The information on footprint (and foot) morphology is especially significant because it elucidates the individuality of each person's footprints.[8,11]

Many of these studies were conducted for stature estimation from foot and footprints on mixed populations. The researchers have cautioned that the people from different regions of a country bear different morphological features depending upon their geographical distribution and primary racial characteristics; therefore, a single formula cannot represent all parts of that country or world.[3,30,35–38]

For the stature estimation from foot/footprint parameters, the researchers concluded that toes to heel length measurements in a foot/footprint are more reliable and accurate than from any other measurements like breadth at ball/heel, big toe breadth/length, etc.[3,12,14,18–20,22] This present study aims to estimate the stature from various footprint length measurements in Indian Tamils, an ethnic group in Tamilnadu State, South India. The linear regression analysis method was used for stature estimation since the reliability and prediction of stature estimation are more accurate and reliable with the regression analysis method.[38] The investigation revealed that the correlations of stature with various footprint length measurements from different toes to heel in both left and right are high. The accuracy of regression equations was verified by comparing the estimated stature with actual stature. The estimated values are found close to the actual stature values. Scatter graphs were drawn by plotting various footprint length measurements against statures and scatter graphs analysis showed perfective positive correlation forming an elliptical pattern of the distribution of values, i.e. best fit lines were obtained in all graphs.

2. Materials and methods

The present study was conducted on consented adult male Indian Tamils, an ethnic group residing in Tamilnadu state, South India. Fig. 1 below depicts the site location, i.e. sampling point of this research. This study aimed to estimate stature in a sample of 2,040 bilateral footprints collected from 1,020 adult male Tamil volunteers of ages ranging between 19 and 42 years old. The research procedure followed was in accordance with the approved ethical standards of Universiti Sains Malaysia Research Ethics Committee (Human). Before the sample collection, information such as subjects' name, age, and place of origin was obtained and recorded.

Those with any apparent disease, orthopedic deformity, injury or disorder were excluded from the study. The subjects were confirmed to be descendants from three generations of Tamils to ensure no genetic variation within races that can disrupt the results as stature can be affected by not only environment, but also genetic makeup. Just prior to research participation, the subjects were advised to wash their feet with soap and water. A cleaned plain glass plate of 8 mm thickness was uniformly smeared with "Kores quick drying black duplicating ink 4746" with the help of a footprint roller. The subject was asked to step with the left foot on an inked glass plate with minimal pressure. Then the inked foot was placed on an A4 plain white paper kept aside on a uniform surface and thus the left footprint was transferred. Before lifting the sole from the paper, anatomical landmarks of the feet were marked on the papers close to the footprints which are mid-rear heel point and most anterior point of all toes. Following Robbins[27] and Krishan[3], the designated longitudinal axis (DLA) and baseline (BL) were drawn on the footprints. The DLA is from the pternion (P) landmark at the mid-rear heel margin to the lateral side of the toe 1 pad margin, the axial line touches the rim of the pad margin as it passes forward beyond the length of foot. Base line (BL) is drawn at the rear edge of the foot and perpendicular to the DLA. The base line extends from the landmark P at the rear of the heel in both medial lateral directions while maintaining its perpendicular alignment with the DLA. Its axis can be determined as marked on the footprint using the pro-tractor. With the 90L mark on the footprint placed on the DLA, and the midpoint of the protractor base at pternion, one automatically has the perpendicular BL by drawing a line through the pternion along the base of the protractor. Then five diagonal footprint length measurements were taken from the mid-rear heel point (P) to the most anterior point of each left toe (LT1, LT2, LT3, LT4, and LT5). The left footprint length measurements were designated as PLT1, PLT2, PLT3, PLT4, and PLT5. The procedure was repeated for the right footprint and the right footprint length measurements were designated as PRT1, PRT2, PRT3, PRT4, and PRT5. The landmarks and diagonal length measurements on the left footprint are shown in Fig. 2. The following are the diagonal length measurements taken on the left and right footprint of each male participant. All footprints and information relating to participants were coded with sample ID for anonymity.

2.1. Left and right footprint length measurements

i. PLT1 – length, measurement taken from the mid-rear heel point, pternion (P) to the most anterior point (LT1) of toe 1 on the left footprint.
ii. PLT2 – length, measurement taken from the mid-rear heel point, pternion (P) to the most anterior point (LT2) of toe 2 on the left footprint.