ORIGINAL RESEARCH

Study of Estimation of Stature from Foot Radiographs at a Tertiary Care Centre

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ABSTRACT
Background: Estimation of stature from human foot bones, foot dimensions, foot prints and foot outline reveal that the human foot, its bones and its impressions can successfully be used in estimation of stature in forensic and legal examinations. The present study was conducted to estimate stature from Foot Radiographs in a known population.**Material & Methods:**The present study was a cross-sectional, observational study carried out on 150 individuals to estimate stature from Foot Radiographs in a known population. The following parameters were estimated: Calcaneal pitch angle, Talohorizontal angle, Talocalcaneal angle, Talo-first metatarsal angle, Radiological foot length. The following correlation coefficients were calculated as follows: CPA and height for the right and left foot, THA and height for the right and left foot, TCA and height for the right and left foot, TFMA and height for the right and left foot and RFL and height for the right and left foot.**Results:**Mean calcaneal pitch angles of both sides of the foot were almost identical. They showed a slight negative correlation with the height of the patient. Hence, they may not help to assess the stature of a person. Mean talocalcaneal both the right and left side are almost equal and show a positive correlation with the height of the patient. Hence, they can be used to estimate stature. Mean TFMA of the right foot and left foot shows a slight positive correlation with the stature. Radiographic foot length is more for the left foot compared to the right foot. The right and left radiographic foot lengths were having a positive correlation with the height of the patient, which implies they can help to estimate the stature. Similarly, the mean THA on the left side is more the right side, and they were negatively correlated with the height of the person. Hence, they cannot be used to assess the stature of a person. Among all the parameters, the radiographic length of the left and right foot was more correlated followed by TCA on the left side and right side with the stature. **Conclusion:**The study concluded thatamong all the parameters, the radiographic length of the left and right foot was more correlated followed by TCA on the left side and right side with the stature.
Keywords: Foot Radiographs, Stature, Foot Bones.

INTRODUCTION

Stature is one of four major parameters, along with age, sex and race, that is very important in identifying individuals in forensic anthropology, forensics, and crime scene investigation. It also provides information about many characteristics of a population, including nutrition, health, and genetics (Krishan & Sharma, 2007). Stature comes from the Latin word statura, meaning "height, size of body growth". Stature is measured as a vertical distance from the vertex to the floor. For establishing identity, stature is an important parameter in medicolegal and forensic examination. [2] The mathematical method considers the regression coefficients derived from the measurements of many bones in the body. Foot angle was considered to be one of the reliable dimensions for estimating the stature of an individual. Determining the height by radiological evaluation is essential during natural disasters, mass deaths, and in disintegrated bodies where long bones cannot be found.[3] Stature has been estimated through measurements of long bones such as the tibia, ulna and humerus[4] (which is the gold standard), radiographic material[5] and hand and foot measurements.[6-9] Various methods to estimate stature exist because there are variations in race and ethnicity.[5,8,10] The present study was conducted to estimate stature from Foot Radiographs in a known population.

MATERIALS& METHODS

The present study was a cross-sectional, observational study carried out in the Department of Anatomy, LN

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Medical College and Research Center, Bhopal, Madhya Pradesh (India) on 150 individuals to estimate stature from Foot Radiographs in a known population. Before the commencement of the study ethical clearance was taken from the Ethical Committee of the institute and informed consent was taken from the participants after explaining the study. Male and female in the age group of 21–25 years were included in the study. Pregnant, breastfeeding women, patients suffering from chronic liver, kidney, and heart disorders and patients with a history of foot fracture and bony deformities were excluded from the study. The radiological examination should be done after completion of the skeletal development. The following parameters were estimated in radiographs:

1. Calcaneal pitch angle (CPA)[11-15]
2. Talohorizontal angle (THA)[11-15]
3. Talocalcaneal angle (TCA)[11-15]
4. Talo-first metatarsal angle (TFMA)[11]
5. Radiological foot length (RFL).[11]

CPA[12-15] is used in the diagnosis and severity grading at X-ray of the flat feet in adults. It is the angle of the calcaneus and the inferior aspect of the foot, with various sources giving various reference points. The first line forming the angle is defined as the calcaneal inclination axis, extending from the calcaneus by the inferior portion of the calcaneocuboid joint to the inferior border of the calcaneus[12] or tangential to the inferior distal border of the calcaneus.[13] The second line is defined as extending one of the above lines to the inferior border of the head of the fifth metatarsal bone or the inferior aspect of the medial sesamoid bone of flexor hallucis longus.[14] or parallel to the ground.[15-17]Talocalcaneal angle[18,19] is also called as the kite angle. It is the angle between lines drawn down the axis of the talus and calcaneus. This angle may vary depending on the position of the calcaneus under the talus and stiffness of the foot ligaments. The midtalar line should pass through the base of the first metatarsal, and the mid-calcaneal line should pass through the base of the fourth metatarsal. Normal TCA is 25–40°. TFMA[18]: this angle is formed between the long axis of the talus and first metatarsal on a weight-bearing lateral view. The mean value of the length of the foot, lateral TCA, TFMA, THA, and CPA were measured. The following correlation coefficients were calculated as follows: 1. Correlation coefficient for CPA and height for the right and left foot 2. Correlation coefficient for THA and height for the right and left foot 3. Correlation coefficient for TCA and height for the right and left foot 4. Correlation coefficient for TFMA and height for the right and left foot 5. Correlation coefficient for RFL and height for the right and left foot. All the readings were statistically analyzed using SPSS Version 20.0 by IBM for windows statistical package program.

RESULTS

Mean calcaneal pitch angles of both sides of the foot were almost identical. They showed a slight negative correlation with the height of the patient. Hence, they may not help to assess the stature of a person. Mean talocalcaneal both the right and left side are almost equal and show a positive correlation with the height of the patient. Hence, they can be used to estimate stature. Mean TFMA of the right foot and left foot shows a slight positive correlation with the stature. Radiographic foot length is more for the left foot compared to the right foot. The right and left radiographic foot lengths were having a positive correlation with the height of the patient, which implies they can help to estimate the stature. Similarly, the mean THA on the left side is more the right side, and they were negatively correlated with the height of the person. Hence, they cannot be used to assess the stature of a person. Among all the parameters, the radiographic length of the left and right foot was more correlated followed by TCA on the left side and right side with the stature.

Table 1: Foot parameters of patients

Foot Parameters	Mean ± SD	Correlation coefficient
Height	163.5±9.6	
CP right	24.5±1.30	-0.08
CP left	24.51±1.30	-0.091
TCA right	30.4±1.11	0.078
TCA left	30.4±1.11	0.078
TFMAright	2.54±0.94	0.059
TFMA left	2.54±0.94	0.059
THA right	44.6±5.76	-0.02
THA left	45.5±5.65	-0.021
RFL right	22.6±1.75	0.77
RFL left	22.7±1.87	0.78

DISCUSSION

Stature estimation is one of the important factors of personal identification. The use of the proposed formula to predict the stature of a particular population is not suitable for other populations because regions have different gender, race, climate, and nutrition.[20]

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Park S, et al (2021) aims to develop a Korean-specific equation predicting stature using radiographic measurements in the contemporary Korean population. The result showed a statistically significant correlation between metatarsal length and stature in Korean populations (male, R = 0.46, $p < 0.001$; female, R = 0.454, $p < 0.001$). Values of correlation coefficients (R) of the equations were 0.431 to 0.477. Compared to equations derived from other races, the Korean-specific equation showed significantly lower error values for estimating the actual height of Koreans through cross-validation.[21]

Gwani AS et al (2017) hypothesized that foot length measured excluding the phalanges, the truncated foot length, may be more reliable in stature estimation than full foot length. All the dimensions measured were significantly larger in males than females. Linear regression equations were derived for estimation of stature using both the truncated foot length and full foot length. The regression equations derived from truncated foot length have larger correlation coefficient, coefficient of determination, adjusted coefficient of determination as well as smaller standard error of estimation than those derived from full foot length. This study suggests that even if the full foot length is available, excluding the phalanges may give more accurate stature estimation.[22]

Singh V et al 2020 aims to measure the radiographic foot angles in different age groups of the North Indian population, National Capital Region, New Delhi, correlating it with the height of the individual. Results concluded that, among all the parameters, the radiographic length of the left and right foot was more correlated followed by TCA on the left side and right side with the stature. The correlation equation came to be Y = 69.97 + 4.18*X (Y = height and X = radiographic foot length for the right foot). The correlation equation was Y = 72.7 + 4.05*X (Y = height and X = Radiographic foot length for the left foot).[23]

CONCLUSION
The study concluded thatamong all the parameters, the radiographic length of the left and right foot was more correlated followed by TCA on the left side and right side with the stature.

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