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Estimation of stature from the length of the sternum in South Indian females

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ABSTRACT

Estimation of stature is one of the principal elements in practical forensic casework involving examination of skeletal remains. The present study was undertaken to estimate stature from the length of the sternum in South Indian females using a linear regression equation. The material for the present study consisted of intact sternums belonging to adult females of South Indian origin aged between 25 and 35 years of age obtained during medico-legal autopsies. The length of the sternum was measured as the combined length of the manubrium and the mesosternum (body of the sternum) from the incisura jugularis (central suprasternal notch) to the mesoxiphoid junction along the mid–sagittal plane using vernier calipers. A linear regression equation [Stature = 111.599 + (3.316 × Length of the sternum)] was derived to estimate stature from the length of the sternum. The correlation coefficient was 0.639. The standard error of the estimate was 4.11 cm. The present study concludes that the length of the sternum is a reliable predictor of stature in adult South Indian females and can be used as a tool for stature estimation when better predictors of stature like the long bones of the limbs are not available when examining skeletal remains.

1. Introduction

Estimation of stature is an important objective in the identification of an individual from dismembered and skeletal remains in forensic case work. Stature estimation, however, is a constantly changing target for forensic anthropologists because of the secular trends in stature, allometric changes in long bones, and the migration of world population. Stature formulae or equations derived from recent and relevant samples provide the most accurate and precise stature estimates. It has been emphasised that for stature estimation in forensic case work, equations based on forensic statures, and the equations based on modern samples should be used.[1] A literature review of recently conducted studies on estimation of stature in forensic anthropology reveals that stature of an individual can be effectively estimated from the hand and foot dimensions,[2–4] segments of the foot,[5] footprint and foot outline.[6] Kanchan et al.[7] derived a universal regression formula for stature estimation from the foot length, while Krishan et al.[8] have reported the effect of limb asymmetry on the estimation of stature. Different cephalo-facial dimensions and facial measurements have also been used to predict stature of an individual.[9–11] Besides, stature has been estimated from cranial sutures,[12] percutaneous length of the tibia and ulna,[13] small bones of the foot and hand[14–16] using statistical equations and formulae.

Estimation of stature by the mathematical or statistical methods is a routine practice in the creation of an anthropological profile in establishing the identity of human skeletal remains. The mathematical method for stature estimation during examination of skeletal remains is primarily based on correlation between distinct

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bones and stature. The various regression equations or formulae based on measurements of distinct bones are specific for sex and population or ethnicity and should be applied accordingly.[17] Regression equations with the lowest standard error of the estimate are those using the femur and tibia as these lower limb bones form part of the individual's stature.[18] However, there are occasions in practical forensic case work when preferred skeletal remains are not always available and an attempt at estimation of stature must be made from other available skeletal remains.[18] Linear regression equation for stature estimation from the length of the sternum in the adult female population of South India is not documented in the forensic literature. The present research was hence, undertaken to study the correlation between stature and the length of the sternum and derive the regression equation for estimation of stature from the length of the sternum in the adult female South Indian population.

2. Material and methods

The material for the present study consisted of 40 intact sternums belonging to adult females of South Indian origin aged between 25 and 35 years of age obtained during medico-legal autopsies conducted at Kasturba Medical College, Manipal and A. J. Institute of Medical Sciences, Mangalore, both in coastal Karnataka, South India during 2009–2010. The age of the subjects autopsied was retrieved from the information furnished by the police in the inquest documents and further confirmed on interviewing the legal heirs before the conduction of the medico-legal autopsy.

Subjects other than those of South Indian origin were not included in the present study. Krogman and Iscan state that 95 percent of the adult stature is achieved at around 21 years of age,[19] and hence, subjects below the age of 25 years were excluded from the study. Unidentified bodies were not included in the study since the age at death opined in these cases was an estimation and not specifically accurate. The bodies that were decomposed, charred, mutilated, and with acquired or congenital physical deformities affecting the measurement of stature were excluded from the study. The bodies with deformities of the chest wall and the sternum like severe degree of pectus excavatum, severe degree of pectus carinatum or sternal fissure, fractured sternum, and gross sternal swelling or abnormal growth affecting the measurement of the length of the sternum were excluded from the present study.

Stature or the length of the cadaver was measured in cm from the vertex of the cranium to the base of the heel with the body placed in a supine position on the autopsy table using a steel measuring tape according to the technique described by Nagesh and Kumar.[20] The sternal plates were dissected according to the technique described by Gordon et al.[21] The length of the sternum was measured in mm as the combined length of the manubrium and the mesosternum (body of the sternum) from the incisura jugularis (central suprasternal notch) to the mesoxiphoid junction along the mid–sagittal plane using vernier calipers in accordance with the technique described by Ashley.[22] The length of the xiphoid process was not considered in the present metric study because of high variability in its size and shape.[23] Sternums with ossified proximal end of the xiphoid process were not included in the study. The xiphoid process often unites with the body of the sternum at around 40 years of age,[24] and hence, subjects beyond the age of 35 years were excluded from the present study. Thus, all the sternums studied were without any acquired or congenital deformity, with a non-united xiphisternum and belonged to adult South Indian females aged between 25 and 35 years of age.

The data obtained were computed and analyzed using SPSS (Statistical Package for Social Sciences, version 11.0) computer software (SPSS, Inc., Chicago, IL, USA), to derive a linear regression equation for stature estimation. To assess the correlation between the length of the sternum and stature, Pearson's correlation coefficient was calculated and its significance was tested by Student's *t*-test. *P*-value of less than 0.05 was considered significant.

3. Results

The mean (±S.D) age of the study sample was 28.85 (±4.42) years. All the individuals in the study sample belonged to the 25–35 years age group. Stature ranged from 146 cm to 168 cm with a mean (±S.D) of 155.88 (±5.27) cm. The length of the sternum ranged from 11.90 cm to 15.80 cm with a mean (±S.D) of 14.12 (±1.07) cm. The length of the sternum formed 9.06 percent of the stature. A linear regression equation [Stature = 111.599 + (3.316 × Length of the sternum)] was derived to estimate stature from the length of the sternum. The correlation coefficient was 0.639. The coefficient of determination was 0.408. The standard error of the estimate was 4.11 cm. The results derived from the present study were statistically significant ($P \leq 0.001$).

4. Discussion

In the present study we assessed the correlation between the length of the sternum and stature in the South Indian female population and derived a linear regression equation for stature estimation with the length of the sternum as the independent variable. Though mathematical sex determination from the sternum has been researched thoroughly in different populations worldwide over the years,[25–30] stature estimation from the length of the sternum has been rarely researched.[31–33] Dwight found that the length of the sternum formed 9.65 percent of the stature in the white male population and 9.22 percent in the white female population.[31] Dwight, a professor of anatomy at the Harvard University in the US had published his paper in the Journal of Anatomy and Physiology in 1890.[31] Dwight concluded that his study seemed probably as trustworthy a basis for stature estimation as the long bones and hoped that some other researchers may think it worthwhile to add to the observations made by him.[31] In the present study, the proportion of the length of the sternum as a percentage of the stature in the South Indian female population was comparable to that reported by Dwight.[31] Menezes et al.[32] derived a linear regression equation to estimate stature from the length of the sternum in the South Indian male population wherein the correlation coefficient was 0.638, similar to the present study. The standard error of the estimate in the South Indian female population reported here was 4.11 cm which is lesser when compared to 5.64 cm in the South Indian male population.[32] The correlation between the length of the sternum and stature in the South Indian population is higher when compared to the North Indian population wherein Singh et al.[33] reported a correlation coefficient of 0.318 for a similarly measured length of the sternum and stature in both males and females. The standard error of the estimate in the South Indian population is lesser than that when estimating stature from a similar length of the sternum measured in the North Indian population wherein Singh et al.[33] reported 6.83 cm and 6.65 cm for males and females, respectively.

In the recent past, linear regression equations to estimate stature from various parameters like the vertebral column length, hand length, middle finger length, foot length, leg length and the arm span are studied in the South Indian female population. Nagesh and Kumar estimated stature of South Indian females from the various segments of the vertebral column.[20] Rastogi et al. estimated stature of South Indian females from the hand length[34] and the middle finger length.[35] Nachiket et al. estimated stature of South Indian females from the foot length.[36] Mohanty et al. estimated stature of South Indian females from the leg length and the arm span.[37] The importance of the present study lies in the fact that this is the first study to report a linear regression equation for