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ESTIMATION OF STATURE FROM HAND DIMENSIONS: A STUDY ON SUB-ADULT FEMALE BENGALEE HINDU CASTE POPULATION, WEST BENGAL, INDIA

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ABSTRACT

Stature is one of the basic indicators of the biological profile that can aid in defining the physical identity of an individual in case of catastrophic events. Many forensic studies have been conducted in different populations worldwide, including India, to estimate stature from hand dimensions but majority of those were on adult populations and comparatively less reported among the sub-adult group, which is urgent since, the formula derived for stature estimation in the adult population is mismatched to sub-adults. Present attempt is to investigate the relationship between hand dimensions and stature among the sub-adult Bengalee Hindu girls of West Bengal, India with formulisation of standard equations to estimate stature from hand dimensions. To achieve this purpose measurements of different hand dimensions and stature were taken from 342 sub-adult Bengalee Hindu girls aged between 10 and 14 years, following standard technique and appropriate landmarks.

No significant bilateral variation of the measurements was noticed, but significant ($p<0.001$) positive correlation was found between all the hand dimensions and stature. However, among all the hand dimensions, the left hand length (LHL) was found to be the best predictor for the estimation of stature. Therefore, it can be concluded that, hand length in general, specifically the LHL, is perhaps the best estimator of the stature of the Bengalee Hindu sub-adult girls and can be useful in forensic cases by enforcement agencies of medico-legal aspects. Present study also vindicated that these predictions/ and or estimations of stature are not applicable to other populations, because

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of growth differentials in anthropometric characteristics, due to diversity of ancestral gene pool and variation of socio-demographic factors.

Keywords: *Forensic Anthropology, Stature, Hand Dimensions, Sub-adult population, Identification, Medio-legal, Justice.*

INTRODUCTION

Forensic anthropology is an applied discipline that involves diverse applications of biological anthropological knowledge which interacts with other disciplines pertaining to the understanding of medico-legal problems, in the service of justice (Lynneruo, 2013; Ubelaker, 2018; Panjakash *et al.,* 2019). The initiation and roots of this field are anchored in comparative human anatomy and methodology has developed through experimentation such as, the assemblage of documented collections, databases and thoughtful research design (Lynneruo, 2013). Forensic anthropology represents a mature scientific field that continues to evolve and advance through new, innovative global researches (Ubelaker, 2018) and this field becomes important as the scientific techniques for foul play have been becoming more and more sophisticated (Panjakash *et al.,* 2019). Stature is one of the basic indicators of the biological profile that can aid in defining the physical identity of an individual over the time and space (Açikgöz *et al.,* 2020; Ghosh *et al.,* 2018) and constitutes one of the "big four major anthropological parameters" that are important in forensic identification, along with age, gender, and race (Krogman and Iscan, 1986). It helps to distinguish between multiple individuals who have the same ancestry, age and sex, thus provides a circumstantial or presumptive identification of an individual. Stature estimation, in personal identification in forensic anthropology from hand dimension and other post cranial bones has been subject matter of extensive research mostly from adult population, however, little in known from sub-adult group.

There is increase in the number of catastrophic events now a days, causing mass death from natural (flooding, cyclones, tsunamis, earthquakes) and man-made and/or accidental (plane crashes, train crashes, terrorist attacks, mass accident, bomb blasts, war, rape, murder, child trafficking, crime scene) errors that usually require the identification of victims from fragmentary and dismembered human remains (Jee and Yun, 2015). In this background, the stature prediction, occupying relatively the central position, can be estimated using two major methods, namely the Mathematical method and the Anatomical method. The Mathematical method takes advantage of the higher linear correlation between long bones and stature. With a long bone as the dependent or independent variable, one can utilize regression equation that reflects the relationship between an individual's stature and the chosen long bone while the Anatomical method, more commonly referred as "Fully's Method", reconstructs stature by summing the measurements of the skeletal elements that contribute to the height and adding a correction factor for the soft tissue (Lundy, 1985; Krishnan, 2007). Among these, the Mathematical method (regression) is more advantageous as it is workable even if a single long bone or its fragments are available where Anthropometry (Lundy, 1985) plays a great role since it is the traditional and perhaps the standard tool of Biological Anthropology. Anthropometry includes a series of systemized measuring techniques that expresses quantitatively the dimensions of living person and skeleton of human body that has a long tradition of use in forensic sciences (Linda, 2006), but almost all from adult population, where sub-adult groups were of limited resource.

A large pool of researches has been found on stature estimation from various skeletal remains and body segments, including the long bones of the lower and upper extremities (De Mendonca 2000), bi-acromial and bi-iliac lengths (Ghosh *et al.,* 2018), foot measurements (Ghosh *et al.,* 2015), and also from percutaneous measurements (Das *et al*., 2012) . In consideration of contemporary situations, the peripheral parts of the body such as hand and foot are mostly the remains in case of accidental and/or man-made disasters. Many forensic studies have been conducted in different populations worldwide to estimate stature from hand dimensions such as, from hand length HL and breadth. In India, such studies (Kanchan *et al.,* 2010) have been commonly reported in forensic case work pertaining to adult populations and less reports from sub-adult groups. Studies regarding establishment of standards for stature estimation is also essential in sub-adult population as the formula derived for stature estimation in the adult population perhaps insufficient and might erroneous for the sub-adults. In the case of growing individuals, it is probably more useful to estimate age than stature. Once the age is stabled, estimation of stature can reduce the pool of possible victim matches even further.

Looking at the paucity of studies pertaining to estimation of stature from both hand dimensions among children (sub-adults) in India and usefulness of these studies in forensic and legal medicine, the present study, probably a maiden attempt, was designed to find out whether any correlation exists between the stature and hand dimensions among the Sub-adult Bengalee Hindu girls. Subsequently, a set of linear regression equation for estimation of stature from hand dimensions was made to use these equations actively and successfully in forensic sciences.

MATERIALS AND METHODS

Study design and sampling: This cross-sectional study was conducted on 399 sub-adult school-going girls of Bengalee Hindu population of Madhyamgram, 24 Parganas (N), West Bengal, India. The eligibility criteria for recruitment of the participants included age range between 10–14 years and apparently healthy individuals with no physical deformity. Purposive cum convenient sampling method was utilized for this study. Prior to conducting this study, the purpose of the study was explained and then verbal and written consent were obtained from the participants, guardians and the school authority.

Measurement of body dimensions: Anthropometric measurements were taken following the standard technique and appropriate landmarks (Lohmann *et al.,* 1988) and stature was measured to the nearest 0.1 cm using anthropometer. Hand length (HL) and hand breadth (HB) were taken to the nearest 0.1 cm using Martins sliding callipers. Hand dimensions were taken using using standard landmarks and standard anthropometric techniques following Lohmann *et al.,* (1988).

Statistical analysis: After taking the measurements, Technical Error of measurement (TEM) was checked (Ulijasek and Kerr, 1998)) which was found without deviation and the distributions of variables were in normality (Shapiro-Wilk, 1965). Descriptive and inferential statistics (correlation, and linear regression) were computed, and the cut off was set as $p<0.001$.

RESULTS AND DISCUSSION

The distribution of selected anthropometric variables including stature and different hand dimensions (Table-1) revealed a mean age of 13.02 ± 1.645 years and a mean stature of 147.46±7.9 cm. Examination of hand length (HL) and hand breadth (HB) revealed no bilateral asymmetry. The multiplication factor analysis (Table-2) revealed least mean value for HL and comparatively higher mean value for HB. However, the HL and HB revealed significant ($p<0.001$) difference between HL and HB. Examination on the results demonstrated greater strength of HL to predict the estimation of stature by HL, in comparison to HB.

Table-1: distribution of stature and hand dimension of participants

Variables (n=342)	**Range**	**Mean ± SD**
Age (years)	10 - 16	13.02 ± 1.645
Stature (cm)	125.40 - 164.50	147.4649 ± 7.9047
Right Head Length (RHL) (cm)	12.00 - 17.70	14.6228 ± 0.9451
Left Hand Length (LHL) (cm)	12.10 - 17.60	14.5801 ± 0.9467
Right Hand Breadth (RHB) (cm)	5.40 - 7.80	6.6877 ± 0.3962
Left Hand Breadth (LHB) (cm)	5.50 - 7.60	6.6175 ± 0.3808

Table-2: Multiplication Factors of different hand dimensions for Stature

Variables	Mean ± SD
Stature/ RHL	10.0999 ± 0.4229
Stature/ LHL	10.1292 ± 0.4144
Stature/ RHB	22.0832 ± 1.0757
Stature/ LHB	22.3150 ± 1.0892

RHL: Right Head Length; LHL: Left Hand Length; RHB: Right Hand Breadth; LHB: Left Hand Breadth

To enhance the power of estimation of stature, linear regression analysis and multivariate regression analysis were undertaken (Table-3, Table-4, Table-5). As can be seen in Table-3, stature showed significant ($p<0.001$) positive correlation with all of the hand dimensions . However, correlation was somewhat stronger ($r = 0.775$) with left hand length (LHL), which also envisaged best prediction by coefficient of determination (R^2 = 0.6), that is explained 60% of variance to estimate the stature.

Table-3: Correlation coefficient (R) and Coefficient of determination (R2) between stature and different hand dimensions

Variable	Predictors	*r*	R^2	*p*-value
Stature	RHL	0.767**	0.589	0.000
	LHL	0.775**	0.6	0.000
	RHB	0.634**	0.401	0.000
	LHB	0.619**	0.383	0.000

RHL: Right Head Length; LHL: Left Hand Length; RHB: Right Hand Breadth; LHB: Left Hand Breadth

Regression analysis was conducted to determine the better predictor, among the four hand measurements. The linear regression equations were also computed (Table-4) and results demonstrated best linear regression equation model for LHL (left hand length), in comparison to other hand dimensions. The overall standard error of estimation (SEE) ranged between 5.01 to 6.23, which denotes high accuracy for all hand dimensions to predict stature of the present sample of sub-adult Bengalee Hindu girls. A low SEE value denotes higher accuracy in stature prediction. Since the LHL showed least SEE value and the highest R^2 value, compared to other variables, it can be considered an efficient predictor for stature among the studied population.

Table-4: Linear regression formulae for stature estimation from different hand dimensions

Variables	Regression Model	SEE	R^2	*R*	*p*-value
RHL	6.419*RHL+53.607	5.08	0.589	0.767	0.000
LHL	6.470*LHL+53.131	5.01	0.600	0.775	0.000
RHB	12.642*RHB+62.918	6.13	0.401	0.634	0.000
LHB	12.849*LHB+62.433	6.23	0.383	0.619	0.000

RHL: Right Head Length; LHL: Left Hand Length; RHB: Right Hand Breadth; LHB: Left Hand Breadth

Multiple linear regression equation model (Table-5) revealed a lower value of SEE at 4.942 and a higher value of R^2 (0.618), which was only slightly higher than that of LHL (R^2 =0.6). Therefore, the present study considers perhaps the bivariate model (LHL to predict stature) is better than composite multivariate dimensions.

Table-5: Multiple linear regression formula for stature estimation from hand dimensions.

Variables	Regression model	SEE	R^2	*r*	*p*-value
RHL, LHL, RHB, LHB	43.607+1.526*RHL+4.0* LHL+1.484*RHB +2.009*LHB	4.94235	0.618	0.786	.000

RHL: Right Head Length; LHL: Left Hand Length; RHB: Right Hand Breadth; LHB: Left Hand Breadth

CONCLUSIONS

Literature survey revealed that studies on stature estimation from body dimension, specially from hand dimensions, among the Bengalee Hindu population are scanty. Furthermore, the available studies mainly pertain to adult populations and only a few on sub-adults. It is therefore important to investigate sub-adults because the formulae derived for stature estimation of the adult population cannot be applied to sub-adults. From the results of the present study, it is concluded that the HL, specially the LHL, can be successfully used for estimating stature of sub-adult Bengalee Hindu sub-adult girls of West Bengal, in forensic practice by enforcement agencies, forensic anthropologists and forensic scientists. However, these equations for estimation of stature are not applicable to other populations due to growth differentials in anthropometric characteristics due to diversity of ancestral gene pool and variation of socio-demographic factors.

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