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RESEARCH ARTICLE

Hand outlines: A New Dimension in Forensic Examination

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Abstract

Stature estimation is central dogma in Anthropo – forensic examinations. It aids in Personal identification of individuals. The purpose of this paper is to study hand outlines as an evidence to predict stature. The study was carried out at Udaipur district, Rajasthan. The samples were collected from males and females of Bhil – a schedule tribe within age groups ranged from 18 – 60 years. This study examines measurements taken from 204 adult subjects (91 male; 113 female). Various anthropometric measurements were used such as Stature, Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines. The results were analyzed statistically using SPSS 20.0 software program. Statistical analysis revealed that sex differences were found to be significant for all measurements at $p< 0.01$ by Student's t-test. Pearson's correlation was found to be statistically significant between stature and all the variables for both males and females. Linear regression equations were calculated with a standard error of estimate (SEE) ranged from ±4.71 cm to ±5.32 cm for males and from ±4.61 cm to ± 5.80 cm for females. In terms of outlines SEE ranged from ±4.80 cm to ±5.32 cm for males and from ±4.84 cm to ±5.80 cm among females. It is evident from the study that measurements taken from hand outlines can better predict stature with a minimum error of estimate difference 0.52 among Bhil males and 0.96 among females. Thus, it was concluded that stature can be determined successfully using hand outline as a parameter. This will give a new perspective and dimension in the field of forensic anthropology and forensic Science by which the stature can be predicted. It was suggested that more studies are needed in this direction for future perspective.

INTRODUCTION

Over the last few decades the subject of Anthropology has evolved from a mere descriptive phase to analytical phase and further to interpretative phase. In this process many disciplines have modified their approaches in order to cope up with newer methodology. An applied discipline of Physical Anthropology is Forensic Anthropology. Forensic Anthropology is concerned with the application of anthropological knowledge and techniques in legal context. When mutilated and amputated limbs or parts of the body are found in natural hazards or in crime scene, personal identification becomes an essential issue and hence identification of commingled mutilated remains is a challenge to forensic experts. A forensic examiner has continuously used anthropometry in forensic investigation to determine biological profile of decreased such as age, sex, ethnicity, stature. And according to them, Stature Estimation is one of the important parameter to identify individuals and is most widely used in forensic examination along with age, sex and ethnicity when dismembered remains are involved. And thus, there is a need of studies on estimation of stature from different parameters of body to establish partial identity of individuals which can help in narrowing

down the pool of possible victim matches. Now, Due to non availability of complete skeleton at crime scene in most of the cases, forensic experts are forced to use mathematical models or formulae as compare to anatomical method to derive stature as it is workable even with a single long bone.

A literature review of recently conducted studies on estimation of stature in forensic domain reveals that stature can be effectively estimated from various parameters. Some authors have successfully tried to predict stature from hand length, foot length, phalange length (Bhatnagar et al 1984, Saxena 1984, Kapoor 1987, Jasuja and Singh 2004, Sunil et al 2005, Sanli et al 2005, Agnihotri et al 2007, Ilayperuma et al 2009, Laila et al 2009, Kanapurkar & Radke 2012, Vijeta and Kapoor 2012, Kapoor et al 2013). Some from isolated long bones or other bones (Kaur et al 2011, Boldsen 1984, Trotter and Gleser 1952, Holland 1992), even from cranial sutures (Jagadish et al 2009) some from the length of sternum (Menezes et al 2011), some from length of index and ring finger (Krishan et al 2012, Sen et al 2014), some from cephalo-facial anthropometry like (Krishan and Kumar 2007, Krishan 2008), Some used anthropometric measurements from computed tomography of metacarpal bones to estimate stature (Zaher at al 2011), Some attempted from foot prints (Reel et al 2012, Hemy et al 2013) and also from hand prints (Ishak et al 2012, Dey et al. 2014).

This paper attempts to introduce a new dimension in the field of forensic examination as hand outlines to estimate stature. It is very likely to found contour of hand in crime scene and thus helpful in forensic investigation. The primary objective of this research study was to access the reliability and accuracy of using the parameters of hand and hand outline for estimating stature in a tribe of Rajasthan.

Material and Methods

The study was carried out at Udaipur district, Rajasthan. The samples were collected from males and females of tribe Bhil within age groups ranged from 18 – 60 years. This study examines measurements taken from 204 adult subjects (91 male; 113 female) of one endogamous group- Bhil. Subjects were given an information regarding the research study and were required to sign a consent form before participating in the study. Each subject was required to fill in a questionnaire containing basic demographic profile (e.g. sex; age; ethnicity). Only individuals without any medical history of hand were recruited for the study.

- Anthropometric Measurements used in present study:

All anthropometric measurements like Stature, Right & Left Hand Length using sliding calipers, Right & Left Hand Breadth using sliding calipers, Right & Left Hand length from outlines taken on paper, Right & Left Hand Breadth from outlines taken on paper. Stature of each subject was measured using a portable Anthropometer following standard procedure (Weiner and Lourie, 1981).

- Techniques for obtaining Hand Outlines:

Just prior to research participation the subjects were advised to wash their hand with soap and water. Then the subject was requested to place his/her hand on a white A4 paper with the palm facing downwards keeping the fingers close together with the thumb stretched to the maximum. Tracing of the hand was made with a lead pencil. The tracing proceeded from the radial styloid process to the ulnar styloid process. A line was drawn joining the two styloid tips. This line is designated as the interstyloid line and the figure so obtained is designated as Hand Outline.
The straight distance between the mid-point of the interstyloid line to the most anterior point of the middle finger was measured as hand length (Amirsheybani et al, 2001). Hand breadth was measured as the maximum distance between the radial side of 2^{nd} metacarpophalangeal joint to the ulnar side of 5^{th} metacarpophalangeal joint on the Hand Outline taken on paper.

Measurements were taken from both the right & the left hand of the subjects. The measurements were taken in centimeters. The results were analysed statistically using SPSS 20.0 software program.

Result

The descriptive statistics for all the nine measurements (Stature, Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines) are shown in Table 1. The mean stature of the Bhil males was 163.56 with standard deviation ±5.57 and in females mean stature was found

152.62 with deviation ±6.40. The values of all of the measurements in case of males are higher than in females and the differences among males and females are statistically significant at p<0.01 by student's t-test.

Table – 1 shows various measurements for both male & females.

Variable	Sex	No. of subjects	Mean	Standard Deviation	T-test
Stature	Male	113	163.56	5.57	13.04**
	Female	91	152.62	6.40	
R Hand length	Male	113	19.30	1.11	11.85**
	Female	91	17.48	1.07	
L Hand length	Male	113	19.24	1.10	12.59**
	Female	91	17.33	1.04	
R Hand length (Hand Outlines)	Male	113	19.37	1.05	12.04**
	Female	91	17.67	0.92	
L Hand length (Hand outlines)	Male	113	19.15	0.98	12.01**
	Female	91	17.58	0.86	
R Hand breadth	Male	113	8.26	0.39	13.13**
	Female	91	7.58	0.39	
L Hand breadth	Male	113	8.15	0.39	14.39**
	Female	91	7.47	0.38	
R Hand breadth (Hand outlines)	Male	113	8.08	0.46	9.937**
	Female	91	7.44	0.45	
L Hand breadth (Hand outlines)	Male	113	8.06	0.46	10.32**
	Female	91	7.38	0.46	

** p<0.01

Table-2 Illustrates Pearson's correlation coefficient with coefficient of determination between dependent Variable (Stature) and explanatory variables (Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines) and Regression Equation among males of tribe – Bhil. All the measurements was found statistically significant correlation with stature at p<0.0001. The overall highest correlation among males was exhibited by Right hand length which is 0.539 cm. And, in terms of hand outlines highest correlation was exhibited by right hand length 0.513 cm. The overall correlation coefficient ranges from 0.307 cm - 0.539 cm. Among hand outlines the correlation coefficient ranges from 0.307cm -0.513cm.

The value of coefficient of determination with stature as Dependent Variable and Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines as Explanatory Variables among males was tabulated. The highest value of coefficient of determination among males was 0.291 and in terms of outlines it is 0.263. This means 30% of total variation in stature was explained by the explanatory variables and 26% of total variation in stature can be explained by parameters of hand outlines.

Linear regression equations were calculated with a standard error of estimate (SEE) ranged from ±4.71 cm to ±5.32 cm for males. In terms of outlines SEE ranged from ±4.80 cm to ±5.32 cm for males.

Table -2 represents Pearson's correlation coefficient with Coefficient of determination between dependent variable and explanatory variables and regression equation among Bhil males.

Variable	Pearson Correlation Coefficient	Coefficient of determination	p- value	Regression Equation	Standard Error of Estimate
R Hand length	0.539	0.291	0.000	Y=111.250+2.710(x)	4.71
L Hand length	0.532	0.283	0.000	Y=111.884+2.686(x)	4.74
R Hand length (Hand Outlines)	0.513	0.263	0.000	Y=111.156+2.706(x)	4.80
L Hand length (Hand outlines)	0.476	0.226	0.000	Y=112.059+2.690(x)	4.92

R Hand breadth	0.349	0.122	0.000	Y=122.273+5.000(x)	5.24
L Hand breadth	0.328	0.108	0.000	Y=122.493+4.792(x)	5.24
R Hand breadth (Hand outlines)	0.307	0.095	0.000	Y=133.496+3.721(x)	5.32
L Hand breadth (Hand outlines)	0.354	0.126	0.000	Y=129.353+4.247(x)	5.23

Table-3 shows pearson's correlation coefficient with coefficient of determination between dependent variable (Stature) and explanatory variables (Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines) and Regression Equation among females of tribe – Bhil. All the measurements was found statistically significant correlation with stature at $p<0.0001$. The overall highest correlation among females was exhibited by Right hand length which is 0.698 cm. The same result was observed among hand outlines of females that right hand length shows highest correlation 0.659 cm with stature. And the overall correlation coefficient ranges from 0.434 cm - 0.698 cm in females. Among hand outlines the correlation coefficient ranges from 0.434 cm -0.659 cm.

The value of coefficient of determination with stature as dependent Variable and Right & Left Hand Length, Right & Left Hand Breadth, Right & Left Hand length from outlines, Right & Left Hand Breadth from outlines as explanatory variables among males was tabulated. The highest value of coefficient of determination among females was 0.487 cm and in terms of outlines it is 0.434cm. This means 48% of total variation in stature was explained by the explanatory variables and 43% of total variation in stature can be explained by parameters of hand outlines.

Linear regression equations were calculated with a standard error of estimate (SEE) ranged from ±4.61 cm to ± 5.80 cm for females. In terms of outlines SEE ranged from ±4.84 cm to ±5.80 cm for females.

Table – 3 Illustrates pearson's correlation coefficient with coefficient of determination between dependent variable and explanatory variables and regression equation among Bhil females.

Variable	Pearson Correlation Coefficient	Coefficient of determination	p- value	Regression Equation	Standard Error of Estimate
R Hand length	0.698	0.487	0.000	Y=79.758+4.168(x)	4.61
L Hand length	0.673	0.454	0.000	Y=80.971+4.132(x)	4.76
R Hand length (Hand Outlines)	0.659	0.434	0.000	Y=71.917+4.566(x)	4.84
L Hand length (Hand outlines)	0.634	0.403	0.000	Y=69.432+4.734(x)	4.98
R Hand breadth	0.535	0.286	0.000	Y=85.545+8.852(x)	5.44
L Hand breadth	0.542	0.293	0.000	Y=85.272+9.013(x)	5.41
R Hand breadth (Hand outlines)	0.528	0.279	0.000	Y=96.918+7.485(x)	5.47
L Hand breadth (Hand outlines)	0.434	0.188	0.000	Y=108.113+6.029(x)	5.80

Discussion:

Previous studies have found that regression equation derived from one ethnic group do not apply to predict stature in another ethnic group (Davies, et al. 1980). As certain factors such as Heredity, environment, nutrition, gender, age, physical activity, socio-economic status, races, rituals has influence over the stature (Malina, 1994).

In the present study, the mean stature of the Bhil males was found 163.56 with standard deviation ±5.57 and in females mean stature was found 152.62 with deviation ±6.40. The values of all of the measurements in case of males are higher than in females and the differences among males and females are statistically significant at $p<0.01$ by

student's t-test. Similar results were reported by Habib and Kamal, 2010 in their study to estimate stature from hand and phalanges lengths of Egyptians. Thus, it can be said that there is a genetic difference between males and females and thus formula for one sex cannot be applied for other sex. (Krishna & Sharma, 2007).

The study revealed that Pearson's correlation (r) was found to be statistically significant between stature and all the variables for both males and females. This means that the linear regression model fits well to the observed data. The overall highest correlation i.e. 0.698 cm was exhibited by females with stature as dependent variable and Right hand length as explanatory variable. And, in terms of hand outlines the overall highest correlation i.e. 0.698 cm was also exhibited by females with stature as dependent variable and Right hand length as explanatory.
Among males, the overall correlation coefficient ranges from 0.307 cm - 0.539 cm. and in terms of hand outlines correlation coefficient ranges from 0.307cm - 0.513cm.
Among females, the overall correlation coefficient ranges from 0.434 cm - 0.698 cm. And in terms of hand outlines correlation coefficient ranges from 0.434 cm -0.659 cm.
It can be concluded that the parameters are more efficient to estimate stature for females as compare to males. Similar results were reported by Shintaku & Furuya, 1990 that the accuracy in predicting stature is more among females than in males.

The highest value of coefficient of determination (r^2) among males was 0.291 and in terms of outlines it is 0.263. This means 30% of total variation in stature was explained by the explanatory variables and 26% of total variation in stature can be explained by parameters of hand outlines. Among females, the highest value of coefficient of determination was 0.487 cm and in terms of outlines it is 0.434cm. This means 48% of total variation in stature was explained by the explanatory variables and 43% of total variation in stature can be explained by parameters of hand outlines. The value of coefficient of determination confirms that parameters of hand Outlines can effectively be used in stature estimation and also females are better predictor of stature. Hence, r and r^2 values both confirm that hand outline parameters can be used to predict stature.

Linear regression equations was derived for all the anthropometric measurements with a standard error of estimate (SEE) ranged from ±4.71 cm to ±5.32 cm for males and from ±4.61 cm to ± 5.80 cm for females. In terms of outlines SEE ranged from ±4.80 cm to ±5.32 cm for males and from ±4.84 cm to ±5.80cm among females. It was noticed that stature can be predicted from hand outlines with a minimum error of estimate difference 0.52 among Bhil males and 0.96 among females. Similar results were observed by Dey et al. 2014 while taking hand prints as a parameter to estimate stature and concluded that stature estimation was gender specific as the parameters are more efficient predictors in stature estimation for females than males and regression equations derived indicated that the stature can be estimated with standard error of estimate ranging from 4.58 to 5.42 in case of males and 4.61 to 5.88 in case of females. It is evident from the study that measurements taken from hand outlines can better predict stature both in males and females. Thus, it was concluded that stature can be determined successfully using hand outline as a parameter. This will give a new perspective and dimension in the field of forensic anthropology.

Conclusion:
Stature is one of the most important criteria in personal identification and is central dogma in Anthropo – forensic examinations. It helps forensic scientists, anatomists, anthropologists in legal settings. Hand Outlines being a new dimension in the field of forensic examination may proved to be a better predictor of stature in situations where it was difficult for the forensic expert to develop fingerprints or hand prints from the crime scene. In this kind of situation, contour of hand or outline of hand was found useful to determine identity by determining stature. Regression equation derived in this paper can be used to accurately estimate stature of tribe Bhil of Udaipur District, Rajasthan. It was concluded that stature can be determined successfully using hand outline as a parameter. This will give a new perspective in legal setting by which the stature can be predicted. It was suggested that more studies are needed in this direction for future perspective.

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