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Stature Determination from the Hand Dimensions among the Adolescent Boys and Girls of Ladakhi Population of Jammu and Kashmir (India)

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Abstract. Forensic anthropologists and pathologists have solved various mysteries like identifying victims and documenting crimes. They have identified the remains of decomposed, partially skeletonised and burned victims. For identifications, the parameters like sex, stature, age and ancestry are the foremost essential components. Present cross-sectional study was carried out on 206 Ladakhi subjects (129 males and 77 females) aged between 14 to 19 years by random sampling method. Classifications were done on basis of standards given by Martin & Saller, (1957) and Vallois, (1965). The hand parameters showed significant sexual dimorphism in adolescent boys and girls at ($p<0.001$) of Ladakhi population. Analysis showed that hands parameters in adolescent girls are found to be more reliable and applicable for stature estimation than in boys. Regression equations showed that multiple regressions are better in predicting the stature than the linear regression in Ladakhi adolescents. The present study revealed that like other body dimensions like long bone length, cephalofacial dimensions, foot dimensions, etc., hand dimensions can also be applied for stature reconstruction when only hand are available for forensic examinations.

Keywords: Forensic anthropology; Biological profiling; Medico-legal stature estimations; Hand parameters.

1. Introduction

Identification of dismembered human remains is one of the foremost objectives of any medico-legal and anthropological investigations where humans are involved. The human remains may be in form of skeleton, mutilated, burnt remains encountered in traffic crashes, explosions and other mass disasters which require personal

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identification[1]. Anthropometry plays an important role in quantifying the human body and skeleton. It is a technique use to take measurements on living, dead or skeletal remains of the deceased person[2]. Examination of the skeletal remains and integrated remnants in legal procedure is covered by forensic anthropology, law enforcement agencies and police related science which is essentially focuses on fixing the biological profile of differences through estimation of the sex, stature and ethnicity[2]. By constructing the biological profile (osteobiography) one can narrow down the pool of victims by specifying sex, age, ethnicity and stature estimation that needed to match and allowing for definite workers, such as DNA to be later used for the confirmation of final identification[3]. The stature estimation for the first time was measured from the individual bones[4].

The stature estimation standards are based on two major methods the mathematical methods is use when the cases involve incomplete skeletal remains and the anatomical method requires a complete long bones from which regression and multivariate function analysis are used to find the correlation between the bones and living stature[5-7] which is not applicable in mutilated cases, so there is need to develop a new standards that utilize different parts of skeleton[8] which have a practical applicability to estimate the stature from the unknown deceased bones parts and use to estimate the stature in the contemporary population specific-standards. Most cases in forensic anthropology involve incomplete skeletal remains and the technique for stature estimation in such cases frequently uses mathematical method. The linear regression equation, from which the stature is estimated from the single skeletal, is:

$$\text{Stature} = a + bx + \text{SE}\ , \qquad (1)$$

where "*a*" is the y-intercept of the line, "*b*" is the slope, "*x*" is the bone measurement and SE is the standard error. Stature is a sole biological entity in that it can be estimated not only in the living individual, but also from skeleton parts after the death of a person[9]. The body proportions in different populations demonstrate considerable variations, not only because of ethnic origin but also because of the effects of time, geographical context, nutrition, physical activity, and environmen[10,11]. Therefore, biological identity is population specific and no such study has done so far on the Ladakhi adolescent population, hence there is need to establish a standard for the stature estimation among the Ladakhi population as Ladakh is strategically importance

location for India as many war were fought between India, China and Pakistan in 1962, 1972 and 1999 which caused many casualties to Local Ladakhi people. The study was conducted by keeping the following aims in mind of the researcher. Khan *et al.*[12] conducted a similar study for stature estimation from hand length and breadth among Kashmiri population and felt the need for such studies as Kashmir is one of the prone areas of mass causalities. It was reported that different hand variables had a positive and reliable correlation with stature reconstructions in Kashmiris. Present study was conducted to obtain a number of aims and objectives firstly to collect the baseline anthropometric data of adolescent children among Ladakhi population; To find the correlation between the hand variables and stature among the defined population and to estimate stature from hands variables by using linear and multilinear regression analysis.

2. Material and methods

The present study was carried out by descriptive cross sectional sample on 229 adolescent students out of which 129 were boys and 77 were girls between 14 to 19 years of aged, by random sampling method, apparently all the subjects were healthy with no physical deformity. Ethical approval was approved from the Institutional Ethics Committee, Panjab University, Chandigarh (PUIEC) with vide reference no PUIEC/2017/62/A-1/06/02. The subjects were explained the nature of the study in detail and consent were taken from each student before the measurements was taken. The technique of method used for collecting data was random sampling method. Anthropometric measurements such as hand length (HL), hand breadth (HB), index finger length (IFL), ring finger length (RFL) of left and right hand of each subject were measured with the help of Vernier sliding calliper mentioned in Table 1. Hand index was calculated as per the classification given by Martin and Saller[13] Hand index is calculated by dividing hand breadth and hand length multiplied by 100 and different types of hands forms were detected in Table 2. Along with anthropometric measurements demographic information were also noted. Stature was measured on each subject with the help of anthropometric rod. The measurements were taken in centimetres to the nearest millimetres 0.1cm by the techniques given by[14,15]. Hand index was calculated from hand length and hand breadth followed by the technique given by[13] given in Table 2. The statistical analysis was done by using SPSS version[16].

Table 1. Techniques and instruments used for data collection followed by Vallois[14.]

S.No.	Measurements	Instruments	Techniques
1	Height	Anthropometric rod	It is the vertical distance between highest points on vertex to the floor while the subject is sitting in Frankfurt horizontal (FH) plane
2	Hand length	Sliding caliper	It measured the distance between the tips of middle finger t the proximal crease at styloid process of radius and ulna bone.
3	Hand breadth	Sliding caliper	It measured the straight distance between the most prominent points on the head of second metacarpal to the most prominent point on the head of the fifth metacarpal of hand
4	Ring finger length	Sliding caliper	It measured the distance between midpoints of the proximal crease at the base of the ring finger to the tip of the ring finger.
5	Index finger length	Sliding caliper	It measured the distance between midpoints of the proximal crease at the base of the index finger to the tip of the index finger.

Table 2. Types of hands as per classification given by Martin and Saller[13].

Hand types along with range – variation (According to Martin and Saller[14])		Percentage			
		Right Hand Boys	Left Hand Boys	Right Hand Girls	Left Hand Girls
X-40.9	Hyperdolichocheir	0.7%	0.7%	3.8%	3.8%
41.0-43.9	Dolichocheir	15.5%	22.4%	33.7%	36.3%
44.0-46.9	Mesocheir	48.8%	48.8%	41.5%	42.8%
47.0-49.9	Brachycheir	31.7%	21.7%	19.2%	15.5%
50.0-X	Hyperbrachycheir	3.1%	6.2%	1.6%	1.2%

3. Results

Hand variables are important elements for the investigators in the medico-legal studies, forensic anthropologist and the clinical practitioner in identification of mutilated remains in any disastrous act. Many researchers have found significant differences in the hand measurements of different populations which show that the hand variables have adaptive significance and are affected by environment, nutrition and nature of work. It has been proved that hand dimensions is useful for anthropological comparative research. Ladakhi adolescent showed differences types of hand forms as per the classification given by[13]. Ladakhi adolescent boys have Mesocheir (48.8%) hand type in both left and right hand followed by Brachycheir (31.7%), Dolichocheir 15.5%, Hyperbrachycheir and (0.7%) Hyperdolichocheir. In case of girls (41.5%) right, (42.8%) left Mesocheir in both right and left hands respectively followed by (33.7%)

right and (36.3%) left Dolichocheir and (19.2%) right, (15.5%) left Brachycheir given in (Table 2). The descriptive analysis of various hands variables in (Table 3) of the adolescent boys and girls showed that mean value and standard deviation are found to be larger in boys in all the hand parameters than girls and showed significant sexual dimorphism at p<0.001.

Table 3. Descriptive statistics for the stature estimation from hand variables of adolescent boys and girls of Kargil (Ladakh).

Variables	Adolescent girls			Adolescent boys		
	Mean ± S.D	t-value	Sig.	Mean ± S.D	t-value	Sig.
RHL	16.36 ± 0.82	9.625	0.00	17.63 ± 0.82	5.783	0.00
RHB	7.36 ± 0.39	5.924	0.00	8.12 ± 0.38	3.720	0.00
RIFL	6.29 ± 0.39	5.738	0.00	6.69 ± 0.39	4.583	0.00
RRFL	6.38 ± 0.41	6.605	0.00	6.88 ± 0.41	3.839	0.00
LHL	16.37 ± 0.85	4.623	0.00	17.60 ± 1.18	5.664	0.00
LHB	7.30 ± 0.37	4.262	0.00	8.05 ± 0.377	3.297	0.01
LIFL	6.38 ± 0.42	5.988	0.00	6.76 ± 0.40	4.724	0.00
LRFL	6.38 ± 0.41	7.246	0.00	6.01 ± 0.44	4.209	0.00

The correlation coefficient between the stature and the different hand parameters such as hand length and breadth index finger length and ring finger length of both left and right hands in both the sexes' exhibit significant and stronger correlation coefficient with stature (p<0.001)*. Correlation coefficients are higher in adolescent boys than girls. The higher correlation were shown by right hand length which having the correlation coefficient 'R' is 0.649 followed by right ring finger length with 'R' 0.506, left ring finger length with 'R' 0.511, and right hand breadth having 'R' 0.465 among Ladakhi adolescent boys where as in girls the highest correlation exist with right hand length where 'R' =0.555 followed by left hand length where 'R' =0.547 and left index finger length where 'R'= 4.724 among the adolescent Ladakhi girls.

The linear regression equation for the stature estimation derived from hand length, hand breadth, ring finger length and index finger length from both the left and the right hands in both the sexes the standard error of estimation (SEE) which predicts the deviations of estimated stature from the actual stature ranges between ±4.63 and

±5.68 in boys. The left hand showed higher SEE than the right hand in boys. The coefficient of determination (R^2) in case of boys is range between ±0.12 in Left hand breadth to ±0.42 in right hand length which is highest among adolescent boys. In adolescent girls the standard error of estimation (SEE) ranges between ±4.02 in right hand length and ±4.35 in left ring finger length. The SEE is higher in left hands than in right hand in case of adolescent girls. The determination of coefficient is ranges from ±0.13 to ±0.31 among girls as predicted in (Table 5 and 6).

Table 4. Correlation coefficients between the hand variables of left and right hand with stature. ($p<0.01$)*.

Variables	Correlation adolescent boys	Correlation adolescent girls
Right hand length (RHL)	0.649*	0.555*
Right hand Breadth (RHB)	0.465*	0.395*
Right index finger length (RIFL)	0.454*	0.468*
Right ring finger length (RRFL)	0.506*	0.405*
Left hand length (LHL)	0.380*	0.547*
Left hand breadth (LHB)	0.354*	0.356*
Left index finger length (LIFL)	0.469*	0.479*
Left ring finger length (LRFL)	0.511*	0.437*

The multiple regression equation derived from the hand length, hand breadth, index finger length and ring finger length of adolescent boys and girls in (Table 7) for the stature estimation form left and right hands variables the standard error of estimation (SEE) were ±0.36 in girls and ±0.69 in boys. The adolescent boys have higher SEE than the girls. The coefficient of determination (R^2) is ±0.36 in girls and ±0.44 in boys which predicts that the hand variables of boys can predicts more the stature estimation than the hand variables of girls. The correlation coefficient in multiple regressions is ±0.59 in girls and ±0.69 in boys implies the hand variables of boy's shows greater correlation with the stature than girls' counterpart.

Table 5. Linear regression formula for stature estimation from hand variables for adolescent girls. SEE: Standard error of estimation; R^2: Determination coefficient; R: correlation coefficient.

Variables	Regression model	SEE	R^2	R	p-value
RHL	3.26*RHL+102.01	4.02	0.31	0.56	0.00
RHB	4.83*RHB+119.93	4.02	0.16	0.39	0.00
RIFL	5.76*RIFL+119.18	4.27	0.21	0.47	0.00
RRFL	4.71*RRFL+125.40	4.42	0.16	0.40	0.00
LHL	3.09*LHL+104.76	4.05	0.30	0.55	0.00
LHB	4.63*LHB+121.67	4.52	0.13	0.36	0.00
LIFL	5.44*LIFL+120.77	4.24	0.23	0.48	0.00
LRFL	5.06*LRFL+123.15	4.35	0.19	0.44	0.00

Table 6. Linear regression formula for stature estimation from hand variables for adolescent boys. SEE: Standard error of estimation; R^2: Determination coefficient; R: Correlation coefficient.

Variables	Regression model	SEE	R^2	R	p-value
RHL	4.82* RHL+81.80	4.63	0.42	0.64	0.00
RHB	7.40*RHB+106.7	5.38	0.21	0.47	0.00
RIFL	7.00*RIFL+119.90	5.42	0.21	0.45	0.00
RRFL	7.42*RRFL+115.68	5.25	0.26	0.51	0.00
LHL	1.96*LHL+132.31	5.63	0.14	0.38	0.00
LHB	5.67*LHB+120.98	5.68	0.12	0.35	0.00
LIFL	7.08*LIFL+118.81	5.37	0.22	0.47	0.00
LRFL	7.36*LRFL+116.02	5.11	0.29	0.54	0.00

Table 7. Multiple linear regression formula for stature reconstruction from hand variables among adolescent girls and boys. SEE: Standard error of estimation; R^2: Determination coefficient; R: correlation coefficient.

	SEE	R^2	R	p-Value	Regression Equation
Boys	4.55	0.44	0.69	0.00	4.038*RHL+3.899*RHB-1.072*RIFL-.640*RRFL+.196*LHL-1.368*LHB-1.272*LIFL+2.803*LRFL
Girls	4.07	0.36	0.59	0.00	1.204*RHL+1.206*RHB+1.268*RIFL-2.861*RRFL+1.541*LHL+0.327*LHB+1.839*LIFL+0.668*LRFL

4. Discussions

Stature reconstruction is an essential aspect of forensic and anthropological studies. It helps in providing important evidence in the forensic anthropological investigation to

form a personal identification. The present study showed that there exists a significant correlation between the stature and hand parameters such as hand length, hand breadth, index finger and ring finger in the adolescent populations. The result of the present study showed that the boys are significantly taller than their girl's counterparts. The hand length, hand breadth, ringer finger length, index finger length was significantly larger in boys than girls except for the left ring finger length. Many studies conducted on hand parameters for estimation of stature in India and aboard. The correlation coefficients were higher in adolescent boys except for right index finger length and left hand length and left hand breadth shows higher correlation in adolescent in the present study. Krishan & Kanchan[17] found higher correlation coefficient for index and ring finger in male's adolescent than females among north Indian population Agnihotri[18], found the males have higher values for hand dimension than the female adolescents in the Mauritian population as in the present study. Wakode *et al.*[19] found the positive correlation between the stature and the hand length measurements of Maharashtrian region. Kanchan *et al*.[20] reported larger ring index and ring finger length in males among the south Indian population. Rastogi[21] studies on South and North Indian population predicted that males have higher dimensions of hand parameters compared to the females like the present study wherein males have higher hand dimensions. This is probably due to prolonged adolescent growth spurt in boys than their female counterparts due to which males gets more time for their growth (Krishan & Sharma) [22], Malek *et al.*[23].

The body dimensions were affected or influenced by genetic, environmental, nutritional as well as climatic factors. Studies on hands dimensions have showed difference in different ethnic groups study done by Okunribido[24] on Nigerian population predicted that the female hands were wider and shorter than others populations groups outside Africa but in the present study the adolescent boys have wider hand breadth and hand length than their girl counterpart.

Means and Walter[25] found that males have longer right hand than the left hand while females have longer left hand than right hand because the hand dimensions vary with the dominance of the hand. In present study right hand length, right hand breadth and right ringer finger length having R= 0.649; 0.465; and 0.506 showed better correlation than left hand in boys as compared with adolescent girls with R= 0.555, 0.395, and 0.405, similar findings were shown by study of Krishan and Sharma[22]. Malek[23] reported hand length showed better correlation coefficients than hand breadth

in both the males and females of south and north Indian population and the Egyptian population. Mandahawi[26] conducted hand anthropometric studies on Jordanian population showed that the Jordanian females have generally longer finger segment than those of Bangladeshi, Nigerians, Vietnamese and Mexican population when compared with the present study the Jordanian have almost similar hand length, hand breadth in both the sexes. When the present study is compared with the studies done by Nag[27] on Indian women Garret[28] on American population and Davis[29] on British population the present population have smaller hand length and hand breadth dimensions the reason may the age factors as the present study is on adolescent boys and girls as the growth were completed in adult population as the adults are fully matured. Khan, *et al.*[30] studied sexual dimorphism by IFL and RFL on Jammu & Kashmir population from two colleges of Jammu region and found that the Ladakhi population have shorter RFL and IFL as compared to Jammu region the reason may genetic environmental and nutritional factors. Khan *et al.*[12] found that right hand length and left hand length shown good correlation with (r=0.626 & r=0.695) with stature whereas left hand breadth was found poorly correlated with height of a person. In present study, the ring and index finger showed the higher correlation coefficient when compared with the Egyptian population studied by Habib & Kamal[31] with the correlation of coefficient 0.350 and 0.375 whereas the present study showed correlation coefficient of 0.454 and 0.506 for both the left and right hands index and ring fingers, respectively.

5. Conclusions

The present study revealed that like others body dimensions such as cephalofacial parameters, foot dimensions, femoral length etc, hands dimensions are also be applied for stature reconstruction when only any hands parameters are available during forensic examination. The present also reported that hands parameters can give significant reliability in predicting stature in forensic anthropological investigation. The study showed hand length, ring finger lengths are more reliable and applicable in stature prediction than hand breadths and index finger in both the sexes. The present study also showed that the in linear regression and multiple regression analysis standard error of estimation is less in case of girls than boys which predicts that the stature estimation is more accurate and reliable in case of girls of Ladakhi population. Multiple regressions shows better coefficient of determination than linear regression

and will be helpful for the stature estimation among the Ladakhi population. The regression equations formed in the present study can only use to estimate height in Ladakhi adolescent because these are population specific and cannot be use for others population.

Abbreviations

Right hand length (RHL), Right hand breadth (RHB), Left hand length (LHL), Left hand breadth (LHB), Right Ring finger length (RRFL), Right index finger length (RIFL), Left ring finger length (LRFL), Left index finger length (LIFL), Correlation coefficient (R), Coefficient of determination (R^2), Standard error of estimation (SEE).

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Conflict of Interest

There is no conflict of interest regarding the publication of this article.

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