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Original Research Article

DETERMINATION OF STATURE FROM MEASUREMENTS OF HAND LENGTH AND HAND BREADTH; AN ANTHROPOMETRIC STUDY OF KASHMIRI POPULATION

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ABSTRACT

Introduction: Estimation of stature is one of the basic parameters to identify an individual. When intact bodies are to be examined, stature estimation does not pose any problem. But when dismembered human parts are the materials to work with, it is of great challenge. Also, when dealing with human remains, estimating living stature can help to identify an unknown individual because there is a close relationship between the body part dimensions and height.

Aim: As the Kashmir region is known to be prone to disasters like terror attacks and natural calamities, the lack of anthropometric data concerning the local population of the state was felt. This study intends to fill this lacuna and derive regression formulae from the anthropometric data taken.

Material and Methods: The present study was conducted on a sample of 200 Kashmiri medical students (100 males and 100 females) within the age group of 18-25 years, studying in Government Medical College, Jammu. Only those students were taken who have no obvious deformity that can affect the measurements.

Results: It was observed that in males the length parameters show greater correlation than the breadth parameters and the highest correlation is shown by the Right Hand Length (0.626) in males and Left Hand Length (0.695) in females and lowest correlation is shown by Left Hand Breadth (0.046) in males and Right Hand Breadth (0.386) in females. Linear regression equations were also derived from each parameter studied to determine stature from them separately.

Conclusion: It is concluded that dimensions of hand provides good reliability in estimation of stature. The highest correlation coefficient between stature and right hand length in males and left hand length in case of females, with lowest standard error of estimate, indicates that comparatively hand length provides highest reliability and accuracy in estimating stature in both males and females. By deriving the population specific linear regression equations, we can determine the height of a person reliably from the dimensions of hand, provided that the person belongs to the Kashmir region of J&K state.

KEY WORDS: Stature, Hand Length, Hand Breadth, Kashmiri population, Anthropometry, Regression.

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INTRODUCTION

Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of human body and skeleton [1]. In order to identify an individual, it is necessary to establish a biological profile via the estimation of age, race, sex, and stature. Also known as "big four" parameters of forensic anthropology [2]. These form the features of tentative identification [3]. Anthropometry helps us in the construction of biological profile of the deceased. Among these "big four" parameters of the forensic anthropology, estimation of stature is considered as one of the main parameter for personal identification. By this process we can narrow down the pool of victims needed to be matched, allowing for more definitive markers, such as DNA, to be later used for the confirmation of the final identification [4]. The estimation of stature can be helpful to law enforcement agencies and other related with police sciences [5]. Besides this, stature provides an insight into various other features of a population including nutrition, health, genetics, geographical location, environment and climatic condition. Stature is also considered as one of the parameters of personal identification. It is an inherent characteristic, the estimation of which is considered to be an important assessment in the identification of unknown human remains [6].

Height estimation is also required for the assessment of growth of children, calculation of nutritional indices of children and adults for prediction and standardization of physiological parameters such as lung volumes, muscle strength, glomerular filtration, metabolic rate and for adjustment of drug dosage in patients [7].

When intact bodies are to be examined, stature estimation does not pose any problem. But when dismembered human parts are the materials to work with, it is of great challenge. Most methods employ the basic process of comparison. Therefore, identification depends mainly upon the availability and completeness of antemortem records. When dealing with human remains, estimating living stature can also help to identify an unknown individual because there is a close relationship between the body part dimensions and height [8].

Thus, there is always a need of study which helps in the identification of the deceased from fragmentary and dismembered human remains. The study may, in addition, have significance in plastic and reconstructive surgeries of hands and feet, where the available dimensions of extremities can be used in post-traumatic reconstruction of others [9].

Estimation of stature is based on a principle that every body part bears more or less a constant relationship with height of an individual. Various studies in the past have utilized various body parts such as upper and lower extremities including hand and foot dimensions for the estimation of stature [10].

The regression formulae derived for one population does not always give accurate results for other populations [11]. It is generally accepted that the most accurate biological profile is formulated using contemporary population specific standards [12].

In conclusion, what may be true for one race or one region may not be true for other. Even within our vast homeland of India, there are many different ethnic groups and they are having their own variations [13].

When current literature was searched, only a few studies were seen to be published regarding the Kashmiri ethnic group of population in India and the need was felt to look for correlation of hand dimensions and their relationship with stature and also to find out population specific equation for estimation of stature from hand length and hand breadth in the Kashmiri population of J & K state.

MATERIALS AND METHODS

The present study was conducted on a sample of 200 medical students (100 males and 100 females) within the age group of 18-25 years from Government Medical College-Jammu, with prior permission from the institutional ethical committee.

Inclusion Criteria: Apparently healthy, asymptomatic males and females of age group 18-25 years. Only those students were included in the study whose parents and grandparents were

from Kashmir division of the state of Jammu and Kashmir to keep in view the ethnic peculiarities of the people of Jammu and Kashmir.

Exclusion Criteria: Males and Females with physical deformities and systemic illness affecting stature and hand measurements were excluded from the study. Age groups below 18 years and above 25 years also were excluded from the study.

Methods of Collection of Data: The study was conducted in a separate post-graduate room. The objectives and methods of the study were explained to the sample population and informed consent was obtained, by taking their signatures on the consent form. All measurements were taken at a fixed time of day to eliminate diurnal variation. Three anthropometric measurements i.e., hand length, hand breadth and stature were measured. The hand measurements of both left and right side were measured separately, for each individual.

Instruments Used: Following instruments were used:

Sliding Caliper - It was used for hand measurements. It consists of a long straight bar, a long arm fixed to one end and a sliding sleeve with long arm parallel to first one (Fig. 1).

Stadiometer - It was used to measure vertical height of the subjects. It consists of platform on which the subject stands a long vertical bar which was scaled in millimeters and an adjustable horizontal bar for measuring the highest point of the subject.

Landmarks and Techniques involved in taking anthropometric measurements:

Stature: It is the vertical distance between the highest point on the vertex and platform of stadiometer [14]. The subject was made to stand erect, bare foot on a level platform against the stadiometer bar with his/her back and hips touching the bar, the feet were close to each other and the heals touching the bar, arms hanging by the side. The head of the subject was resting without any strain in the eye-ear plane or Frankfurt's plane i.e., trigone and the infraorbital margin of both the sides lie in the same plane.

Hand Length: It is the projected distance between the midpoint of a line joining the styloid process of radius and ulna bones of forearm and the tip of middle finger (Fig. 2).

Hand Breadth: It is the distance between the most prominent point on the lateral aspect of hand of second metacarpal and the most prominent point on the medial aspect of the hand of fifth metacarpal (Fig. 3).

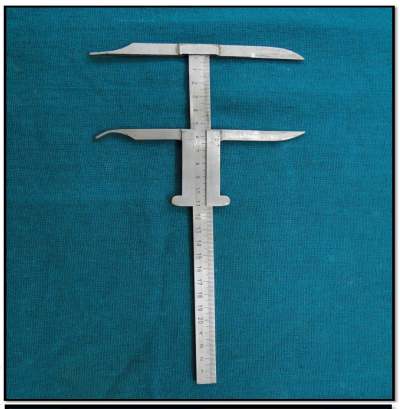

Fig. 1: Vernier Calliper.

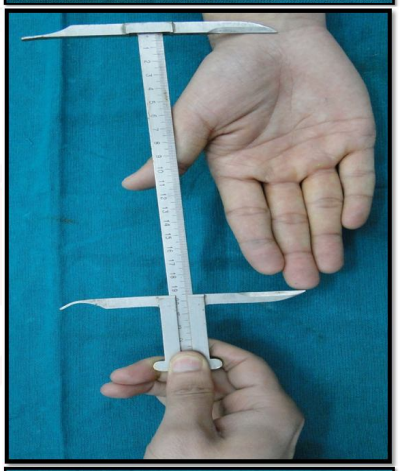

Fig. 2: Procedure for measuring the Length of hand.

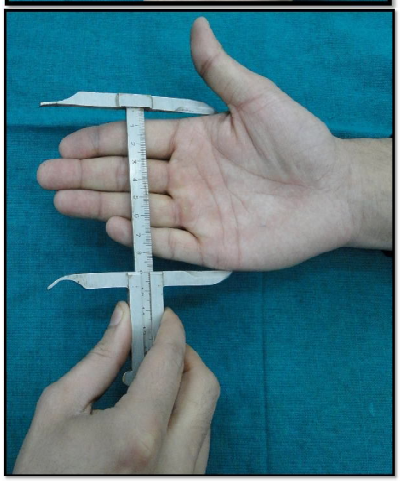

Fig. 3: Procedure for measuring the Breadth of hand.

RESULTS

The results were prepared on the basis of collected data. The regression equation, Pearson's correlation coefficient and various other statistical parameters were calculated using MS Excel Programme and SPSS software version 18.

Table 1: Distribution of stature (in cm) among study population.

	Males	Females	Total
Number	100	100	200
Mean	174.73	158	166.37
Std. Error of Mean	0.637	0.606	0.737
Std. Deviation	6.372	6.065	10.43
Minimum	159	147	147
Maximum	188.5	175	188.5

Table 2: Descriptive statistics of the parameters studied in Males and Females.

	Males				Females			
	Right Hand Length	Left Hand Length	Right Hand Breadth	Left Hand Breadth	Right Hand Length	Left Hand Length	Right Hand Breadth	Left Hand Breadth
Number	100	100	100	100	100	100	100	100
Mean	18.93	18.92	8.6	8.5	17.26	17.2	7.754	7.63
SE of Mean	0.08	0.08	0.035	0.036	0.078	0.079	0.034	0.034
SD	0.8	0.87	0.357	0.363	0.786	0.792	0.341	0.345
Minimum	17.1	17.3	7.8	7.7	16.2	16.2	7	6.9
Maximum	20.4	21	9.3	9.3	19.7	19.7	8.5	8.5

Table 3: Paired sample "t" test showing statistical difference between right and left side in Males and Females.

Paired Samples		Males		Females	
		t-stat	Sig. (2 tailed)	t-stat	Sig. (2 tailed)
Pair 1	Right Hand Length & Left Hand Length	0.699	0.485	6.16	0.000*
Pair 2	Right Hand Breadth & Left Hand Breadth	9.26	0.000*	9.49	0.000*

* . Statistically Significant (p<0.05)

Table 4: Correlation between the stature of an individual and various parameters studied in Males and Females.

Parameter	Males		Females	
	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
Right Hand Length	0.626	0.000*	0.685	0.000*
Left Hand Length	0.611	0.000*	0.695	0.000*
Right Hand Breadth	0.065	0.000*	0.386	0.000*
Left Hand Breadth	0.046	0.000*	0.444	0.000*

* . Correlation is significant at the 0.05 level (2-tailed)

Table 5: Linear regression equation for various parameters in Males and Females.

Linear Regression Equations in Males		Linear Regression Equations in Females	
Stature = Constant + Regression Coefficient (Dimension) ± Standard Error of Estimate	Coefficient of Determination(r^2)	Stature = Constant + Regression Coefficient (Dimension) ± Standard Error of Estimate	Coefficient of Determination(r^2)
Stature = 80.31 + 4.98(Right Hand Length) ± 4.99	0.392	Stature = 66.75 + 5.28(Right Hand Length) ± 4.43	0.47
Stature = 90.16 + 4.46(Left Hand Length) ± 5.06	0.373	Stature = 66.41 + 5.32(Left Hand Length) ± 4.38	0.483
Stature = 164.66 + 1.17(Right Hand Breadth) ± 6.39	0.004	Stature = 104.77 + 6.86(Right Hand Breadth) ± 5.62	0.149
Stature = 167.83 + 0.811(Left Hand Breadth) ± 6.39	0.002	Stature = 98.38 + 7.80(Left Hand Breadth) ± 5.46	0.197

Table 6: Showing the Minimum, Maximum and Mean of the observed value of stature and values predicted by regression equation from various parameters in Males and Females.

	Males			Females		
	Minimum (cm)	Maximum (cm)	Mean (cm)	Minimum (cm)	Maximum (cm)	Mean (cm)
Observed Value (Actual Stature)	**159**	**188.5**	**173.75**	**147**	**175**	**161**
Right Hand Length	165.46	181.9	173.68	152.28	170.76	161.52
Left Hand Length	167.31	183.82	175.56	152.59	171.21	161.9
Right Hand Breadth	173.78	175.54	174.66	152.79	163.08	157.93
Left Hand Breadth	174.07	175.37	174.72	152.2	164.68	158.44

Table 1 shows distribution of stature among study population, ranging from 159 – 188.50 cm in males and 147 – 175 cm in females. The mean stature among males is 174.73 cm with the standard deviation of ± 6.372 cm and the mean stature among females is 158.00 cm with the standard deviation of ± 6.065 cm. The overall mean stature of the population is 165.35 cm with the standard deviation of ± 10.43 cm. **Table 2** shows the descriptive statistics of various parameters studied in males and females. The mean hand length of 18.93 (SD±0.80) cm on right side and mean hand breadth of 8.60 (SD±0.357) cm on right side, both indicate that the various descriptive parameters are more on right side as compared to left side in males. Similarly in females also the mean hand length of 17.26 (SD±0.786) cm on right side and 7.75 (SD±0.341) cm on left side indicates the same thing that the parameters are more on right side. In order to assess the statistical differences between the observations of Right and Left side in males and females separately, paired sample "t" test was performed. The statistical analysis in the **table 3** indicates that the bilateral variations were statistically significant (P<0.05) for all the measurements except Hand Length in males, which was found to be statistically insignificant. **Table 4** shows the correlation of stature with various other parameters studied in males and females. It is also observed that in males the length parameters show greater correlation than the breadth parameters and the highest correlation is shown by the Right Hand Length (0.626) in males and Left Hand Length (0.695) in females and lowest correlation is shown by Left Hand Breadth (0.046) in males and Right Hand Breadth (0.386) in females. All the parameters exhibit statistically significant positive correlation with

stature in both males and females. **Table 5** shows linear regression equations predicting stature using various parameters in both males and females. The equations also exhibit Standard Error of Estimate (SEE).The SEE predicts the deviation of estimated stature from the actual stature. It ranges between ± 4.39 to ± 6.99 in males and ± 4.38 to ± 5.62 in females. Lower values indicate greater reliability in the estimated stature. Right Hand Length exhibits a lower value in males and Left Hand Length in females and thus gives better reliability in prediction of stature. The table also shows the power of prediction or coefficient of determination (r^2), which is a measure of how well the variation in one variable explains the variation of the other. In case of males it is the Right Hand Length which has the highest prediction power (r^2 = 0.392) and the Left Hand Breadth has the lowest prediction power (r^2 = 0.002). While as in case of females it is the Left Hand Length which has the highest prediction power (r^2 = 0.483) and Right Hand Breadth which has the lowest prediction power (r^2 = 0.149). **Table 6** depicting mean predicted value of stature through the regression equation, which is almost similar to the mean observed value; however the minimum and maximum value indicated that there were differences in the predicted and observed value.

DISCUSSION

Over many decades, a close relationship between stature and dimensions of various body segments are reported and the results are frequently used in the medico-legal investigations. In this cross-sectional descriptive study an attempt was made to estimate stature of a person by using its hand length and hand breadth of both sides. Males and females aged between 18 to 25 years, who were born and brought up in the Kashmir region of J&K state were included. As it is not always possible to measure all the variables, so it is useful to have separate regression equations available for each variable. The prediction function was derived through linear regression equations from each parameter for both, males and females, separately.

The results of the present study showed that the dimensions of the hand can successfully be used for the estimation of stature by law enforcement agencies and forensic scientists. The only precaution to be taken into consideration is that these formulae are applicable to the population of Kashmir region only, due to inherent population variations in these dimensions, which may be attributed to genetic and environmental factors like climate, nutrition etc.

In the present study males showed higher mean values in all the parameters studied, than among females and the differences in these measurements was found to be statistically significant ($p<0.001$). Hence our findings reveal a clear pattern of sexual dimorphism with females, consistently having smaller stature, hand length and hand breadth compared to their male counterparts and this is in line with the findings of earlier studies done in this regard by – Isurani et al. [15], Jethva et al. [16] and Numan et al. [17].

These statistical significant differences may be due to the early pubertal growth spurt in girls that stops early, under the influence of estrogen, which causes early fusion of epiphysis. In males although the growth spurt occurs comparatively later, they continue to grow for a longer period under the influence of testosterone. This reason necessitates different equations for males and females.

The mean stature found in our study was 174.73 (SD ± 6.37) cm in males and 158.00 (SD ± 6.06) cm in females. The males having greater stature than females and this difference was found to be statistically highly significant ($P<0.001$). This suggests that the formula for one sex cannot be applied to estimate stature of the other sex.

These results were comparable with the previous studies conducted by Krishan et al. [2], Isurani et al. [15], Jasuja [18] and Krishan and Sharma [19] all of them have observed that the mean stature was greater in males than females.

The mean stature found by different authors in India in different regions or states is slightly different [2] and this can be explained by the different genetic constitution, environmental factors and nutrition in different population groups.

In our study we observed that the hand dimensions of the males are more than the hand

dimensions of females and this difference was statistically highly significant ($p<0.001$). This finding is in agreement with various studies conducted on hand dimensions in different adult populations – Krishan and Sharma [19] in North Indian population; Sanli et al. [20] in Turkish population; Agnihotri et al. [21] in Mauritian population and Kanchan and Rastogi [22] in North and South Indian population also reported larger hand dimensions in males than females.

Variations were also noted in the hand dimensions of same sex in different study populations. Anthropometric parameters like hand dimensions are genetically determined and hence are known to vary between different ethnic groups.

As far as bilateral asymmetry is concerned in our study, both the parameters i.e., hand length and hand breadth, shows statistically significant bilateral asymmetry ($p<0.05$) in both males and females except for the hand length in males, where the bilateral asymmetry was not statistically significant. Our findings are in accordance with the study conducted by Ishak et al. [12] and Krishan and Sharma [19] in which they reported that bilateral variation was statistically significant for hand breadth only. The present study findings are also in consonance with the study conducted by Abdul-Malek et al. [23], in which they demonstrated right and left differences only for hand breadth. Our study is not in accordance with the studies conducted by Agnihotri et al. [21] and Bhatnagar et al. [24] in which they demonstrated no significant differences in right and left dominance.

All the parameters showed statistically highly significant positive correlation with stature in the present study and thus can be successfully utilized for the stature estimation. In males Right Hand Length with correlation coefficient of $r = +0.626$, exhibits comparatively higher correlation with stature. The left hand breadth, with statistically significant, correlation coefficient of $r = +0.046$, exhibits comparatively least correlation with stature. Thus in males, right hand length is the best parameter for the estimation of stature. In females left hand length with statistically highly significant ($p<0.001$) correlation coefficient of $r = +0.695$, exhibits comparatively higher correlation with stature. The right hand breadth,with statistically highly significant, correlation coefficient of $r = +0.200$, exhibits comparatively least correlation with stature. Thus in females, left hand length is the best parameter for the estimation of stature. These observations of our study are in agreement with the study done by Ishak et al. [12], according to which the variable most strongly correlated to stature is hand length – the same relationship was explained for the left and right hand in each sex. Our results were not in consonance with the study conducted by Modibbo et al. [25], where they observed hand breadth was having higher statistically significant correlation ($r = +0.62$) with stature as compared to hand length ($r = +0.60$). Therefore according to this study hand breadth is the best parameter to estimate stature.

Both linear and multiple regression equations were evolved and it was found that by applying these equations, minimum and maximum actual stature and the stature estimated from bilateral hand length among males and females varied but, the mean value of actual stature of males (172.77cm) and stature estimated from bilateral hand length (172.7cm) was almost similar. Similarly, the mean value of actual stature of females (157.92cm) and stature estimated from bilateral hand length (157.92cm) was same.

These findings are in accordance to the study conducted by Krishan and Sharma [19], wherein they also observed greater variation of estimated minimum and maximum stature with respect to the actual minimum and maximum stature, but the mean value estimates were close to each other.

In order to assess the accuracy of our regression equations, the Standard Error of Estimate (SEE) was derived, which predicts the deviation of estimated stature from the actual stature. Lower the SEE value more accurate will be the regression model. In our study the SEE was lowest for the right hand length (SEE ± 4.99cm) in males and in case of females it was lowest for left hand length (SEE ± 4.38cm).

Expectedly, other researches also demonstrated that this is the most accurate measurement for estimating stature, albeit their regression models have a higher accuracy: e.g. Krishan and Sharma ±3.78cm [19]; Sanli et al. ±3.50cm [20] and Rastogi et al. ±3.65cm [26]. This improved

accuracy may possibly be attributed to the lack of diversity in their sample populations, specifically in terms of genetic variability.

CONCLUSION

It is concluded that dimensions of hand provides good reliability in estimation of stature. The highest correlation coefficient between stature and right hand length in males and left hand length in case of females, with lowest standard error of estimate, indicates that comparatively hand length provides highest reliability and accuracy in estimating stature in both males and females. By deriving the population specific linear regression equations, we can now determine the height of a person reliably from the dimensions of hand, provided that the person belongs to the Kashmir region of J&K state. Anatomists, anthropologists, archeologists and medico-legal investigators may find this relationship between stature and hand dimensions of practical use.

As the region Kashmir is very prone to mass casualties, so more research work is supposed to be done on this topic for the identification of individuals from their various other body parts like individual fingers, phalanges, dimensions of feet etc.

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Conflicts of Interests: None

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