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ORIGINAL PAPER

Estimation of Stature from Measurements of Hand Dimensions

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ABSTRACT

Introduction: *Estimation of Stature is sine qua non in the discipline of forensic anthropometry, especially in doubtful medico-legal cases with mutilated or amputated body parts.* ***Aims:*** *Our study aims to derive a correlation between hand length and stature, and to establish regression formulae to estimate stature when hand length is available.* ***Methods:*** *This study was undertaken on 114 females and 86 males (n= 200) of 17-23 years amongst the cosmopolitan population of Western India. The hand length was measured taking two parameters- from the ulnar head and from the dorsal tubercle of Lister to the tip of the middle finger. Stature was measured with a stadiometer. Mathematical formulae were developed separately for both hands through linear regression.* ***Results:*** *We found a strong positive correlation of hand length and stature, the most significant being the left hand radial length (r= 0.8668).* ***Conclusion:*** *With a paucity of data of this kind in western India, an intelligent conjecture can be made using these regression formulae regarding the stature of an individual for identification purposes. This study also has application in the clinical scenario in diagnosing conditions like connective tissue disorders (disproportionate dimensions of the body).*

Keywords*: Forensic Science, Anthropometry, Hand Length, Correlation, Medico legal cases, Bony landmarks, Regression*

INTRODUCTION

Anthropometry is the science of measurement of the human individual, including a variety of parameters that elucidate dimensions of the different portions of the human body. It includes systematic collection of data on the size, shape and proportion of various body parts, and a relative comparison of these proportions under normal and abnormal conditions.

- The parameters include-
- Height (Stature)
- Hand Length
- Foot Length
- Ear Length
- Waist Circumference
- Width of Trunk
- Circumference of Arms and Thighs
- Neck Circumference et al.

The applications of Anthropometric measurements are multifarious, and also fall within the broader discipline of auxology.

Anthropometry and the dimensions of the human body have fascinated man for many centuries. The first man in documented history to use anthropometry was probably the Roman scholar Vitruvius who in 15 BCE said that the ideal body should be 8 heads high. A number of scientists drew inspiration from this, the most notable of whom was Leonardo da Vinci who drew the famous "Vitruvian man", a nude figure of the most perfectly proportioned man. This figure and the accompanying notes outlined the measurements of an ideal human body, based on Vitruvius' notes and da Vinci's own observations.

In the course of forensic studies, there are a number of cases in which measurement of separate parts of the body is essential; especially to estimate attributes like age, sex, stature of an individual. This is pertinent for studying evolution, ergonomics, diagnosis of malnutrition and obesity.

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In the case of Captain K Nagaraju,[1] a doctor in the Indian Army, the identification of the dismembered body of his wife was carried out by the superimposition technique. In certain places, facilities for such sophisticated methods are not available, primarily due to lack of funds. In our study, by simply measuring the hand length, one can estimate stature by inserting the values in the regression equations, which is cost effective and time-saving.

Stature is one of the most important elements of identification of an individual. Establishment of the identity of an individual is essential in cases when only fragmentary remains of human body are found.[2] Such need may arise from mass disasters i.e. bomb blasts, aeroplane crash, stampede, tsunami, earthquake, flood, cyclones, Terrorist attack, close compartment fire, wars, public vehicle(train, bus, ship, plane etc) accidents etc. Mutilation of body could also be possible by humans, animals or by natural process of decomposition.

Genetic and geographical variations exist in different populations. It is a proven fact that stature can be estimated from hand length.[3-8] There is a paucity of data in Western India; hence there is a need for this kind of a study to be undertaken, to aid in doubtful medico-legal cases where only a few body parts of the victim can be retrieved. This is essential taking into account rising crime rates in Maharashtra. While measuring hand length, soft tissue landmarks were taken in the previous studies.[6, 7, 9-12] We have taken 2 bony landmarks – The Ulnar Head and the Dorsal Tubercle of Lister (on the posterior surface of lower part of the radius), and combined the distances measured from both in a single equation for each hand. The bony landmarks being more reliable have given us a very strong positive correlation (r exceeding 0.85 in all our parameters), which is statistically very significant.

MATERIALS AND METHODS

Duration of Study: 2 months

Place of Study: Forensic Medicine & Toxicology and the Department of Anatomy, Grant Medical College & Sir JJ Group of Hospitals.

Type of Study: Cross-sectional study

Sample Size: 200

Healthy, well nourished subjects were chosen free from any physical ailment or diseases affecting external dimensions of the body or any congenital abnormalities of the upper limb**.**

Those who had undergone recent fractures, amputations or nerve lesions were excluded from the study.

Before beginning this study, the Institutional Ethics Committee's approval was obtained and written informed consent was taken from all the subjects.

The Operational definition of Hand Length: 2 measurements were taken on each hand. (**Figures 1 and 2**)

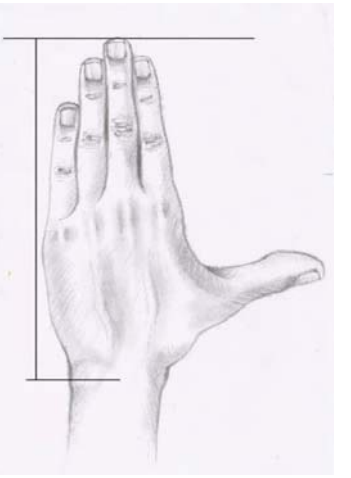

Figure 1 Ulnar length

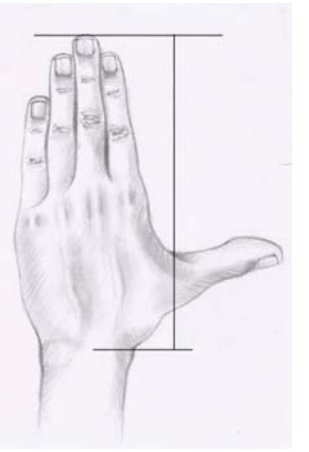

Figure 2 Radial length

1. Ulnar Length - From the Ulnar head on the posterior aspect of Forearm to the tip of the middle finger and

2. Radial Length - From Lister's tubercle on the dorsal aspect of the radius to the tip of the middle finger.

Position - The subject was seated comfortably, with the palm in prone position, fingers adducted and thumb extended. Middle finger was parallel to long axis of forearm. It was measured with the help of a workshop-made graph-scale arrangement (**Figure 2**)

Figure 3 Position of hand on graph-scale arrangement

Stature - Measured as the vertical distance from standing surface to top of head with the help of a stadiometer). Person should stand erect with head in the Frankfurt plane. Heels are together, with weight distributed equally on both feet. Shoulders and the upper extremities are kept relaxed. Measurement taken when subject is breathing quietly (no prior exhausting activities).

Statistical Analysis

Karl Pearson's Correlation Coefficient r was calculated using MS Excel software for the 4 parameters – Right Hand Ulnar, Right Hand Radial, Left Hand Ulnar, and Left Hand Radial Lengths with the Stature.

Linear regression equations were formulated and scatter plots were obtained using MINITAB software. A p value <0.05 was considered to be significant.

OBSERVATIONS AND RESULTS

The study population comprised of individuals aged between 17 and 23 years. Characteristics of the study population are shown in Tables 1, 2 and 3.

Table 1 Stature (cm)

	Female	**Male**
Mean	157.434	170.919
Standard Error	0.587	0.679
Median	157.000	170.250
Mode	157.000	170.000
Standard Deviation	6.270	6.301
Sample Variance	39.316	39.699
Kurtosis	0.544	0.764
Skewness	0.473	0.034
Range	33.500	36.500
Minimum	144.500	152.000
Maximum	178.000	188.500
Sum	17947.500	14699.000
Count	114.000	86.000

Karl Pearson's Coefficients for the parameters are -
Right Hand Ulnar Length and Stature – 0.8553
Right Hand Radial Length and Stature – 0.8509
Left Hand Ulnar Length and Stature – 0.8550
Left Hand Radial Length and Stature – 0.8668
Multiple regression analysis was done and the results are given in table 4.

Table 2 Right hand measurements (cm)

	Ulnar Length		**Radial Length**	
	Female	Male	Female	Male
Mean	17.973	19.892	17.850	19.638
Standard Error	0.080	0.105	0.079	0.105
Median	17.900	19.950	17.700	19.700
Mode	17.600	20.300	17.700	19.700
Standard Deviation	0.854	0.975	0.845	0.971
Sample Variance	0.729	0.950	0.714	0.943
Kurtosis	-0.133	1.438	-0.116	0.572
Skewness	0.439	0.090	0.448	0.024
Range	4.300	6.000	4.200	5.600
Minimum	16.100	16.900	16.000	16.900
Maximum	20.400	22.900	20.200	22.500
Sum	2048.90	1710.70	2034.90	1688.90
Count	114.000	86.000	114.000	86.000

Table 3 Left hand measurements (cm)

	Ulnar Length		**Radial Length**	
	Female	Male	Female	Male
Mean	17.866	19.649	17.913	19.883
Standard Error	0.080	0.101	0.078	0.103
Median	17.750	19.700	17.900	19.900
Mode	17.200	19.700	17.900	20.200
Standard Deviation	0.857	0.932	0.831	0.957
Sample Variance	0.734	0.869	0.690	0.916
Kurtosis	0.189	0.638	0.039	0.910
Skewness	0.453	-0.061	0.388	-0.010
Range	4.700	5.300	4.600	5.600
Minimum	15.700	17.100	15.800	17.000
Maximum	20.400	22.400	20.400	22.600
Sum	2036.70	1689.80	2042.10	1709.90
Count	114.000	86.000	114.000	86.000

Table 4 Regression equations and graphs

Regression Equation		**Actual Data**	**After Removing Points with HI Leverages and Cooks Distance**	**R square**
Right Hand	**Total Sample**	Y=47.632+(3.389)*rh ulnar + (2.787)*rh radial	Y=48.822+(3.693)*rh ulnar+ (2.412)*rh radial	0.741
	Female	Y=64.827+(3.233)*rh ulnar + (1.933)*rh radial	Y=64.48+(4.365)*rh ulnar+ (0.815)*rh radial	0.470
	Male	Y=75.373+(1.463)*rh ulnar+ (3.383)*rh radial	Y=77.065+(0.777)*rh ulnar + (3.971)*rh radial	0.540
Left Hand	**Total Sample**	Y=47.452+(2.015)*lh ulnar+ (4.171)*lh radial	Y=49.076+(1.701)*lh ulnar+ (4.395)*lh radial	0.753
	Female	Y=62.392+(0.911)*lh ulnar+ (4.397)*lh radial	Y=61.117+(0.626)*lh ulnar+ (4.76)*lh radial	0.490
	Male	Y=70.987+(3.068)*lh ulnar+ (1.994)*lh radial	Y=73.201+(3.154)*lh ulnar+ (1.783)*lh radial	0.548

Mini Tab Software was used to plot graphs using our data and Lowess Regression Analysis is depicted in **Figure 4** (Right Hand Measurements and Stature) and **Figure 5** (Left Hand Measurements and Stature).

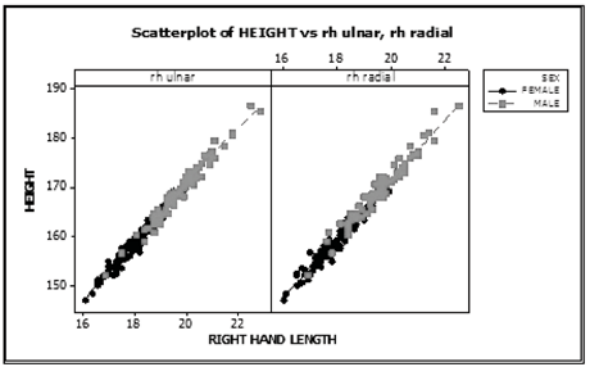

Figure 4 Lowess regression of right hand lengths and stature (rh= right hand, HGT=height)

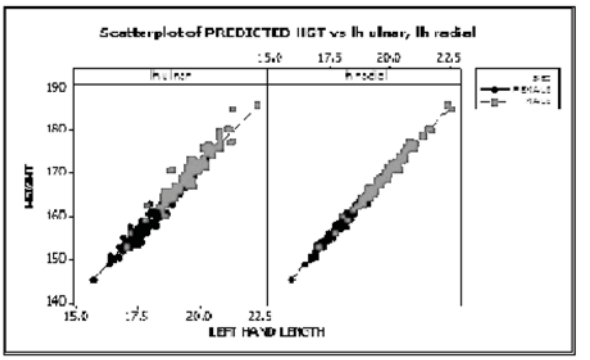

Figure 5 Lowess regressions of left hand lengths and stature (lh=left hand, HGT=height)

DISCUSSION

The aim of our study was to evaluate the accuracy and reliability of using hand length measurements to estimate the stature of an individual. The present study shows a highly significant correlation between hand length and stature, with $p<0.001$.

The best parameter to assess stature was found to be the left hand radial length (i.e. the distance between Lister's tubercle and the tip of the middle finger) with p=5.28*10^-07. Karl Pearson's correlation coefficient for this parameter was 0.8668. In a study conducted by Nilofer et al,[13] the right hand length showed greater correlation with stature (r=0.829) as compared to the left hand (r=0.824).

In a study conducted in Gujarat by Patel et al, arm span (r=0.908) followed by hand length (r=0.806) were found to be the best parameters to assess stature.[3]

Like Nilofer et al,[13] Jasuja O.P. et al,[14] Sanli S et al,[5] Krishnan K et al,[4] Rastogi P et al,[6] Supare et al,[12] we derived regression formulae as well. Pawar et al found that height was approximately 9 times the hand length.[15] There have been studies in the past which correlated the stature and hand length.[16-23] These obtained a positive correlation too, but what sets our study apart from most of these is that we have taken bony landmarks (Ulnar Head and Lister's Tubercle) to measure hand length, which being more reliable than soft tissue landmarks, provide higher precision while calculating stature.

Multiplication factors differed from those obtained in these studies because of the same and also because of genetic and geographical variation.

We have also gone a step further, taking both the ulnar and radial lengths in the same equation, and removing points with Hi Leverages and Cooks distance.

The mean stature of males was 170.919cm, while that of females was 157.434 cm, implying that males are constitutionally taller than females. This is the result of influence of the sex hormones, Oestrogens and Testosterone. The effect of Oestrogen to cause fusion of Epiphysis with shaft of bones is more potent than that of testosterone.[24]

These results are similar to those obtained by Jasuja OP et al,[14] Supare et al[15] and Ilayperuma et al.[9]

Also, mean hand lengths in Males (refer to tables 2 and 3) was found to be greater than that in females. This result is similar to the results obtained in previous studies by Supare et al,[12] Sanli S.G. et al[5] and Lukpata et al.[25]

Variance and standard deviation (Tables 2 and 3) were found to be lesser in females than in males.

Limitations of the Study –

•Sample size is relatively small; hence any conjecture made cannot be extrapolated to the entire human race. •Instrumental and Personal Errors while taking measurements.

CONCLUSION

The present study has established definite strong positive correlation between hand length and stature. We have also obtained Regression Equations and plotted graphs for estimating stature.

This is a study of its first kind, taking into account 2 bony landmarks – namely the Ulnar Head and Lister's tubercle to measure hand length. It will help in several doubtful medico legal cases where only a few body parts of the victim can be retrieved, as well as in mass disasters to identify body parts for adequate disposal as per religious customs. This is important for a city like Mumbai, which being the financial capital of the country, is frequently a target for terrorist activities. In the clinical scenario, this study can aid in the diagnosis of certain congenital anomalies involving disproportionate growth of limbs and body parts.

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Conflict Interest: No conflict of interest associated with this work.

Ethical Clearance: Institutional Ethical Committee clearance was obtained before beginning the study.

Source of Funding: Self-Funded

Contribution of authors: We declare that this work was done by

the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Conception of Idea, Aims and Objectives of the Study and Discussion of Results. Supervision of Data Collection – Dr BG Chikhalkar. Collection of Hand Measurements of 200 students and idea to use bony landmarks – Kuber Bhinde. Collection of Stature Measurements of 200 students and review of literature– Shriya Deshmukh. Statistical Analysis of Data – Dr Prashant Howal. Overall Supervision – Dr SD Nanandkar.

REFERENCES

1. Reddy KSN. Identification of dismembered parts: the medicolegal aspects of the Nagaraju case. *Forensic Sci* 1973 Aug;2(3):351-74.
2. Mohanty SP, Babu SS, Nair NS. The use of arm span as a predictor of height: A study of South Indian women. *Journal of Orthopaedic Surgery* 2001;9(11):19-23.
3. Patel PN, Tanna JA, Kalele SD. Correlation between hand length and various anthropometric parameters. *International Journal of Medical Toxicology and Forensic Medicine* 2012;2(2):61-3.
4. Krishan K, Sharma A. Estimation of stature from dimensions of hand and feet in a north Indian population. *J Forensic Leg Med* 2007 Aug;14(6):327-32.
5. Sanli SG, Kizilkanat ED, Boyan N, Ozsahin ET, Bozkir MG, Soames R et al. Stature estimation based on hand length and foot length. *Clin Anat* 2005 Nov;18(8):589-96.
6. Rastogi P, Nagesh KR, Yoganarasimha K. Estimation of stature from hand dimensions of north and south Indians. *Leg Med (Tokyo)* 2008 Jul;10(4):185-9.
7. Sunil, Dikshit PC, Aggrawal A, Rani M. Estimation of stature from hand length. *J Indian Acad of Forensic Med* 2005;27(4):219-21.
8. Laila SZH, Ferdousi R, Nurunnobi ABM, Shafiqul Islam ATM, Holy SZH, Yesmin F. Anthropometric measurements of the hand length and their correlation with the stature of Bengali adult Muslim females. *Bangladesh J Anatomy* 2009 Jan;7(1):10-13.
9. Mohite PM, Keche AS, Mohite DP, Keche HA. Correlation of the dimensions of hands and feet with the stature of an individual-A study on central Indian adults. *J Indian Acad of Forensic Med* 2015 Jun;37(2):160-4.
10. Ilayperuma I, Nanayakkara G, Palahepitiya N. Prediction of personal stature based on the hand length. *Galle Medical Journal* 2009 Sep;14(1):15-8.
11. Pal A, Aggarwal P, Bharati S, Panda M, Datta I, Roy P. Anthropometric measurement of hand length and their correlation with stature in eastern Indian population. *Natl J Med Res* 2014;4(4):303-5.
12. Supare MS, Pandit SV, Bagul AS. Estimation of stature from hand length and hand breadth in medical students of Maharashtra, India. *Int J Health Allied Sci* 2015;4(3):154-9.
13. Mulla NG, Kulkarni PG, Gangane SD. A study of correlation of stature and hand length in students of Maharashtra. *Int J Emerg Trends Sci Technol* 2014 Aug;12(1):215-8.
14. Jasuja OP, Singh G. Estimation of stature from hand and phalange length. *J Indian Acad of Forensic Med* 2004;26(3):100-6.
15. Pawar PK, Dadhich A. Study of correlation between human height and hand length in residents of Mumbai. *Int J Biol Med Res* 2012;3(3):2072-5.
16. Ahmad N, Mohammad F, Farooque I. Estimation of height from the long bones of upper limb and hand dimensions in south Indian population. *J Evid Based Med Healthc* 2014 Sep;1(7):473-8.
17. Jethva N, Patel SV, Patel SM, Vora R, Parmar G. Estimation of stature from hand length in living subjects of Gujarat region. *Natl J Integr Res Med* 2013;4(4):57-60.
18. Kanchan T, Krishan K, Sharma A, Menezes RG. A study of correlation of hand and foot dimensions for personal identification in mass disasters. *Forensic Sci. Int* 2010 Jun 15;199(1-3):112.e1-6.
19. Uhrová P, Beòuš R, Masnicová S, Obertová Z, Kramárová D, Kyselicová K et al. Estimation of stature using hand foot dimensions in Slovak adults. *Leg Med (Tokyo)* 2015 Mar;17(2):92-7.
20. Abdel-Malek AK, Ahmed AM, el-Sharkawi SA, el-Hamid NA. Prediction of stature from hand measurements. *Forensic Sci Int* 1990 Jul;46(3):181-7.
21. Chawla M, Rajkumar, Ashoka R, Tomar S, Mittal LK. The relationship between hand length and height in adult males of north Indian Punjab population. *Journal of Evolution of Medical and Dental Sciences* 2013 March;2(9):1005-14.
22. Wakode NS, Wakode SL, Ksheersagar DD, Tajane VD, Jachak AN. Prediction of stature based on measurement of hand length in Maharashtra region. *Indian J Clin Anat Physiol* 2015;2(3):131-5.
23. Geetha GN, Swathi, Athavale SA. Estimation of stature from hand and foot measurements in a rare tribe of Kerala state in India. *J Clinical Diagn Res* 2015 Oct;9(10):HC01-04.
24. Guyton and Hall. Textbook of medical physiology. 12th ed. New Delhi: Reed Elsevier India Private Limited; 2013. p-632 and p-643.
25. Lukpata PU, Esomonu UG, Ewununu EO, Mba CE. Correlation between height and selected anthropometric parameters of the upper limb of the Efiks people in Cross River state, Nigeri. *J Pharm Biomed Sci* 2016;6(1):47-50.