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Original Article

Estimation of Stature for Long and Short Bones Utilizing the Line of Correlation

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Abstract

Background: Estimation of stature can be done from length of short and long bones. **Objectives:** The purpose of the present study was to estimate the stature from anthropometry of right and left hand fingers. **Methodology:** The present study consisted of 300 (150 male and 150 female) pre-clinical MBBS and BDS students, 18 to 26 year, Kathmandu Medical College Teaching Hospital, Nepal. All the students were briefed about the study, written consents from the student and ethical boards were taken. Stature, hand length and finger length of student were measured in centimeter by using high board and digital caliper repetitively. Data were analysed by using SPSS. **Results:** The difference of stature, hand length and finger length between male and female subjects were found to be highly significant ($P<0.01$). A positive and highly significant ($p<0.01$) correlation between structure and hand fingers length were observed in both genders. There was also positive and significant correlates between the bilateral hand and finger measurements in both genders. Linear regression equation for stature estimation was derived using hand length and finger length for both genders and checked for their accuracy by comparing the estimated stature and measured stature. The results shows no significant difference between estimated and measured stature which indicated that hand length and finger length provides an accurate and reliable means in estimating the stature. **Conclusion:** Stature of a person can be estimated from short and long bones measurement. [*Journal of Science Foundation, July 2020;18(2):43-53*]

Keywords: Anthropometric measurement; stature; hand length; finger length

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Introduction

Anthropometry is often viewed as a traditional and a basic tool of biological anthropology, but it has a long tradition of use in forensic sciences and it is finding increased use in medical sciences especially in the discipline of forensic medicine (Krishnan et al., 2006). Anthropometry constitutes the technique of expressing quantitatively the form of the human body. There is a long record of discussion on the issue of

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human variation in anthropometric research. The biological profile of a person such as age, sex, ethnicity and stature can be determined with the help of anthropometry (Kanchan et al., 2011). Among these big fours of anthropology, estimation of stature is considered as an important anthropometric parameter to Anthropologist, Anatomist, and in Medico-legal practice (DiMaggio et al., 2011). Stature can be defined as natural height of a person in erect position and is measured from foot to the vertex in anatomical position of Frankfurt plane. The stature prediction occupies relatively a central position both in the anthropological research and in the identification necessitated by the medical jurisprudence or by the medico-legal experts. Estimation of stature has a significant importance in the field of forensic anthropometry. Establishing the identity of an individual from mutilated, decomposed, & amputated body fragments has become an important necessity in recent times due to natural disasters like earthquakes, tsunamis, cyclones, floods and man-made disasters like terror attacks, bomb blasts, mass accidents, wars, plane crashes (Ahmad et al., 2014). Studies on the estimation of stature from the skeletal remains or from the mutilated limbs, mostly of the long bones have been reported as indicated by the published work of the Pearson (1899), Trotter and Glesser (1952). Thus the scientists may have to use mathematical method of stature reconstruction. There are various ways to estimate stature from bones but the most easiest and the reliable method is by regression analysis (Krishnan et al., 2006).

Various studies conducted on the estimation of stature indicate that every part of the skeleton has been used for estimation (Iscan et al., 2001). Many human features have been used to estimate stature from skeletal remains and body parts owing to the established relationship between stature and different parts of the body (Numan et al., 2013). However regression formulae derived for one population do not always give accurate results for other population and studies have stressed that formula for stature estimation should be population specific (Duyar et al 2010). These variations from population to population and ethnic region to ethnic region may be due to differences in nutrition and level of physical activity (Numan et al., 2013).

A number of researchers have carried out the correlation study between stature and various long and short bones of the body. Lots of correlation studies have been carried out between hand dimension and stature and very few studies on stature estimation are reported based on the fingers length has been carried out so far. Even more limited studies are taking into account for all the fingers of both right and left hand (Isak et al., 2010). Thus, present study is planned to find out the relationship of right and left hand length and finger length with body stature and to estimate stature from hand length and finger length among the pre-clinical medical student of Kathmandu Medical College Teaching Hospital, Nepal.

Methodology

The present study was descriptive cross-sectional study which was carried out in Kathmandu Medical College Teaching Hospital (KMCTH), Duwakot, Bhaktapur under Department of Anatomy during the period of one year August 2014 to August 2015. All the subjects included in this study were pre-clinical MBBS and BDS students of KMCTH. A full written consent form was taken from the concerned students and signed by them after the nature and motivation of the study was clearly explained to them and thus thanked for their voluntary participation. Socio-demographic indices like age, gender and ethnicity were also recorded. The study protocol was approved by the ethical committee of KMCTH with the inclusion and exclusion criteria of the study. Young healthy students of KMCTH without any significant diseases or deformities of hand, finger, leg, foot or back were included. In the present study the measurement of stature, right hand length, left hand length, right hand fingers length (thumb, index, middle, ring and little) and left hand fingers length (thumb, index, middle, ring and little) was taken. The measurement was taken twice and the average was recorded to ensure accuracy. The measurement was taken by using standard anthropometric instruments like height board (stadiometer) and digital caliper. Stature was measured using a stadiometer. The stature was measured as the vertical distance from vertex to the foot. The subject was asked to stand with their heels placed together, touching the base of the vertical board while the head, scapulae, back and buttocks were positioned in contact with the vertical backboard. Subject was advised to position the head in the Frankfurt Horizontal plane; a horizontal plane represented in profile by a line between the lowest point on the margin of auditory meatus. Arms were placed by the side of body with palm in a prone position. Then, the movable board was brought onto the most superior point on the head and stature was recorded. Hand length of both right and left hand was measured with the help of digital caliper. The subject was asked to sit comfortably in a chair and asked to place their hands supine on a flat hard horizontal surface with

fingers extended and adducted but not hyper extended. Then, the hand length was measured as a straight linear distance between midpoint of distal crease of wrist joint and distal end of most anterior projecting point that is tip of middle finger. The measurement was recorded in centimeter scale. Finger length of all fingers (thumb, index, middle, ring and little) of both right and left hand was measured with the help of digital caliper. The subject was asked to sit comfortably in a chair and asked to place their hands supine on a flat hard horizontal surface with thumb finger abducted and other fingers extended but not hyper extended. Then the finger length was measured as a straight linear distance between midpoints of proximal finger crease to the tip of finger of respectively. Data analysis was done by using Statistical Package of Social Science (SPSS) 16.0 version. The value of Pearson's correlation coefficient 'r' between stature and hand measurements (hand length and finger length) was derived. Stature of student was estimated from the hand length and finger length by applying regression equation.

Results

The study comprised a total of 300 samples which includes 150 male and 150 female between the age group of 18 to 26 years.

Normality Test of Anthropometric Data: The normality of the data was verified using the Shapiro-Wilk test based on its p-value. P-value <0.05 was considered statistically significant. Since, the data were not found to be statistically significant as their p-value was higher than the considered p-value, the data were considered as normally distributed. If the p-value would have been statistically significant, the data would have been considered as non-normally distributed. Thus, in that case, all non-parametric tests would have been applied. shows the descriptive statistics for normality test of anthropometric data. It was observed that most of the parameters such as stature of male and female, right hand length (RHL), right thumb finger length (RTFL), right index finger length (RIFL), right ring finger length (RRFL), left hand length (LHL), left thumb finger length (LTFL), left index finger length (LIFL), left middle finger length (LMFL), left ring finger length (LRFL), left little finger length (LLFL) in male and RIFL, RRFL, RLFL, LLFL in female were normally distributed except age in male and female, right middle finger length (RMFL) in male, RHL, RTFL, RMFL, LHL, LTFL, LRFL in female, which were non-normally distributed.

Table 1 Descriptive statistics for normality test of anthropometric data.

Parameters	Shapiro-Wilk Test								
	Male (n= 150)	Female (n'= 150)							
	Mean ± SD (cm)	Statistics	df	p-value	Mean ± SD (cm)	Statistics	df	p-value	
Age (years)	20.21 ± 1.25	0.88	150	< 0.05	19.71 ± 1	0.79	150	<0.05	
Stature	170.15 ± 6.27	0.99	150	> 0.05	156.83 ± 4.73	0.99	150	> 0.05	
RHL	18.56 ± 0.87	0.99	150	> 0.05	17.12 ± 0.73	0.98	150	< 0.05	
RTFL	6.44 ± 0.46	0.99	150	> 0.05	5.87 ± 0.40	0.98	150	< 0.05	
RIFL	7.16 ± 0.41	0.99	150	> 0.05	6.60 ± 0.32	0.99	150	> 0.05	
RMFL	7.89 ± 0.53	0.87	150	< 0.05	7.30 ± 0.36	0.98	150	< 0.05	
RRFL	7.37 ± 0.43	0.99	150	> 0.05	6.75 ± 0.35	0.98	150	> 0.05	
RLFL	5.98 ± 0.43	0.98	150	> 0.05	5.43 ± 0.36	0.98	150	> 0.05	
LHL	18.63 ± 0.87	0.99	150	> 0.05	17.12 ± 0.73	0.97	150	< 0.05	
LTFL	6.33 ± 0.45	0.98	150	> 0.05	5.76 ± 0.37	0.98	150	< 0.05	
LIFL	7.18 ± 0.45	0.99	150	> 0.05	6.60 ± 0.35	0.98	150	< 0.05	
LMFL	7.95 ± 0.45	0.99	150	> 0.05	7.30 ± 0.36	0.99	150	> 0.05	
LRFL	7.39 ± 0.44	0.99	150	> 0.05	6.76 ± 0.37	0.97	150	< 0.05	
LLFL	5.97 ± 0.43	0.98	150	> 0.05	5.40 ± 0.37	0.99	150	> 0.05	

Data are presented as mean, standard deviation (SD) in years for age and in cm for other parameters, degree of freedom (df). n: number of male, n'=number of female, RHL: right hand length, RTFL: right thumb finger length, RIFL: right index finger length, RMFL: right middle finger length, RRFL: right ring finger length, RLFL: right little finger length, LHL: left hand length, LTFL: left thumb

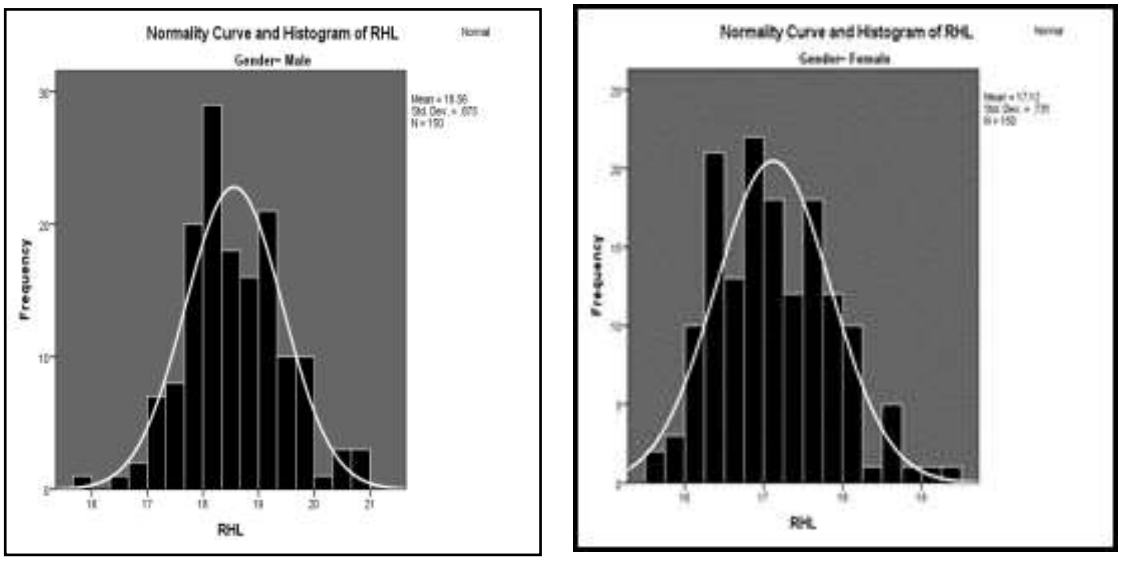

Figure I: Distribution pattern with normality curve of stature in male and female

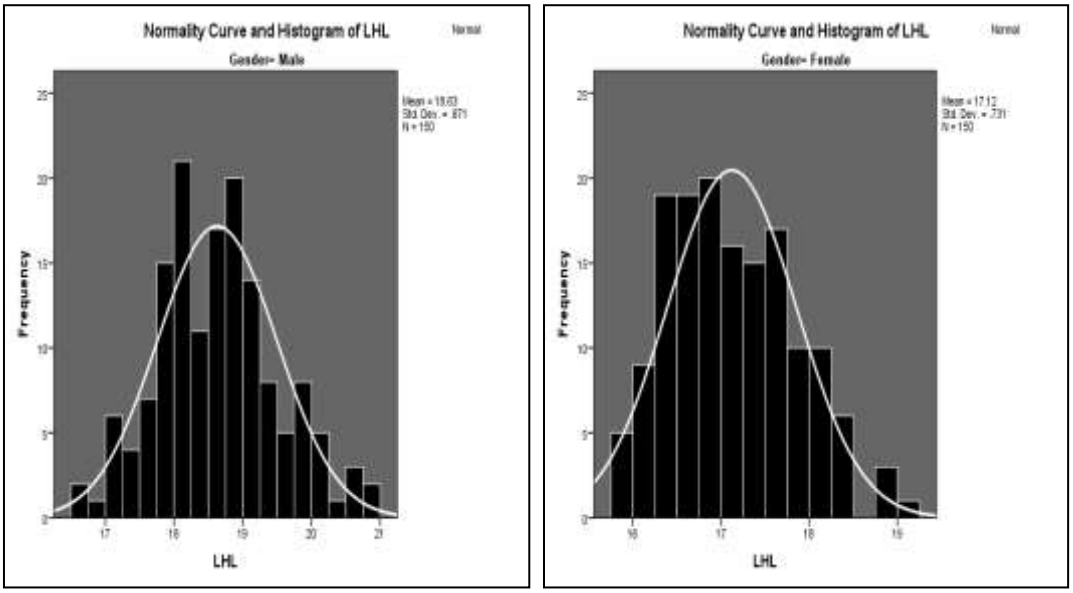

Figure II: Distribution Pattern with Normality Curve of Right Hand Length in Male and Female

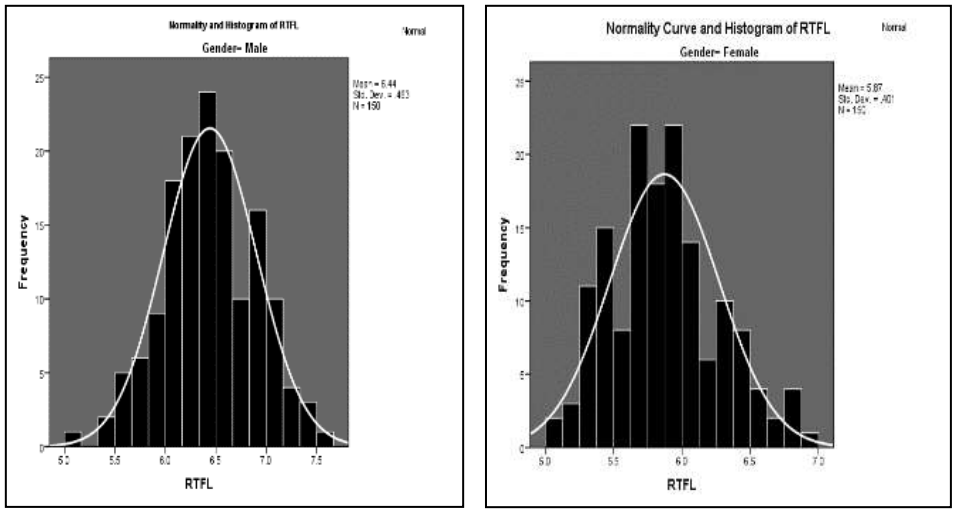

Figure III: Distribution pattern with normality curve of left hand length in male and female

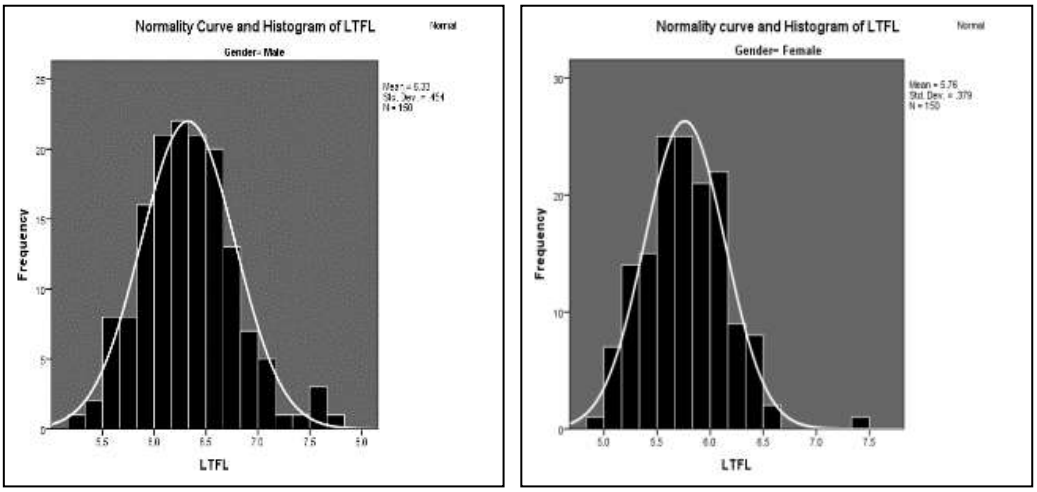

Figure IV: Distribution pattern with normality curve of right thumb finger length in male and female

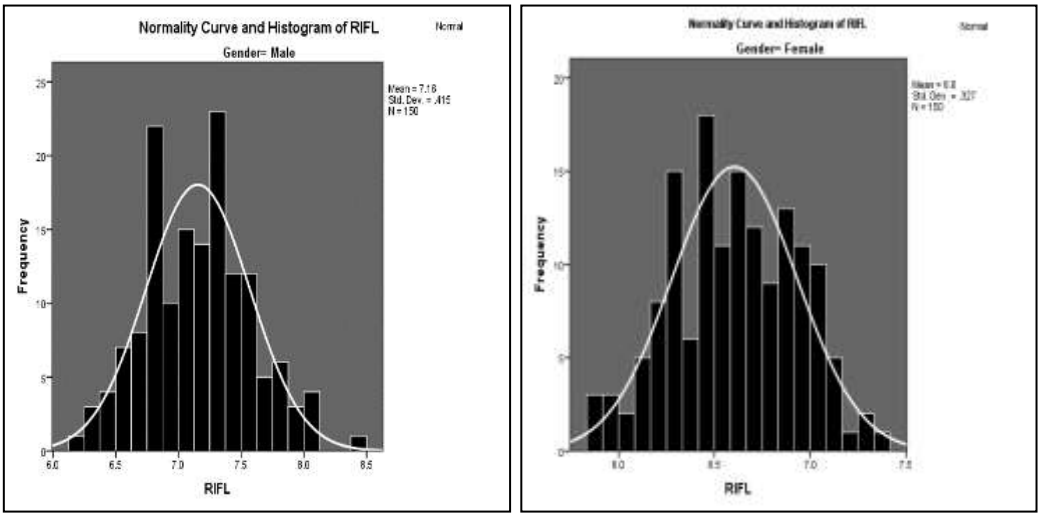

Figure V: Distribution pattern with normality curve of left thumb finger length in male and female.

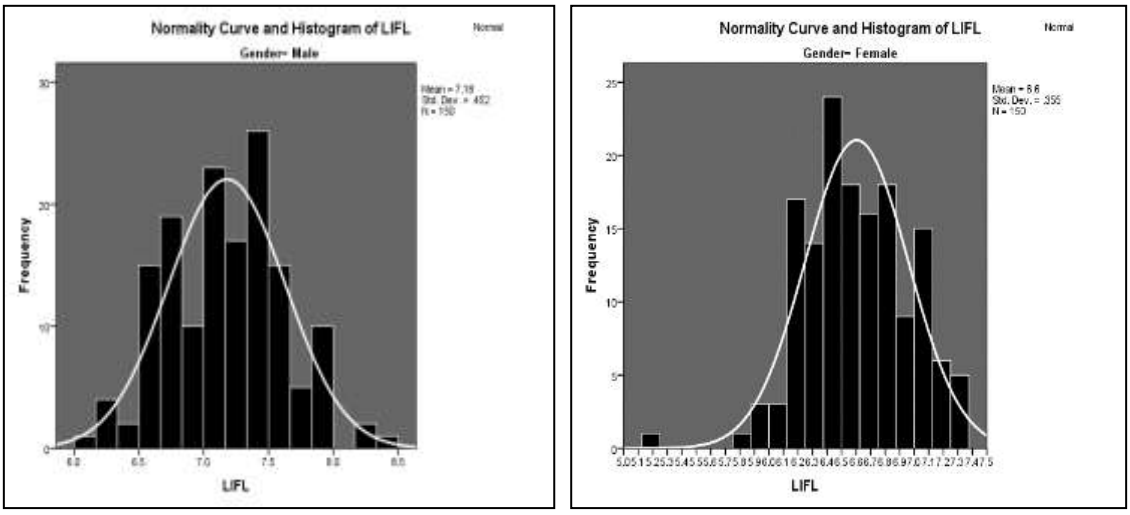

Figure VI: Distribution pattern with normality curve of right index finger length in male and female

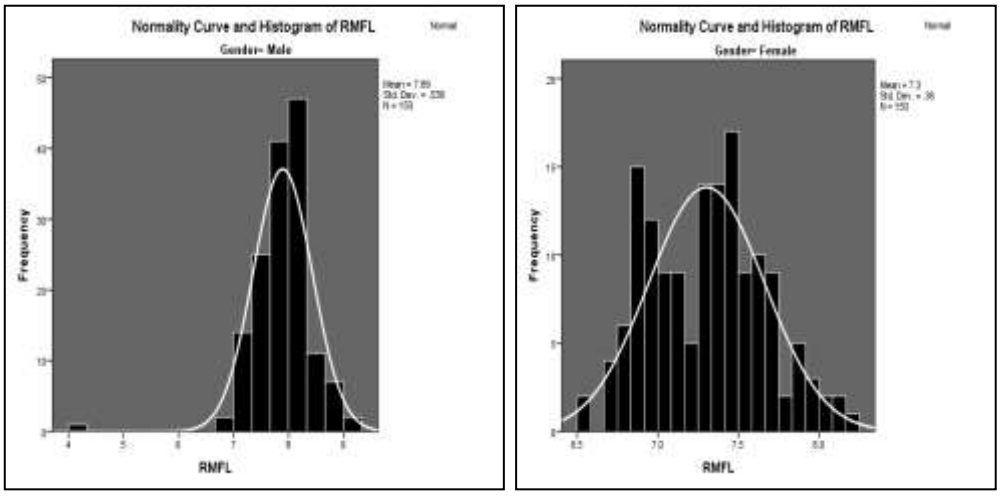

Figure VII: Distribution pattern with normality curve of left index finger length in male and female

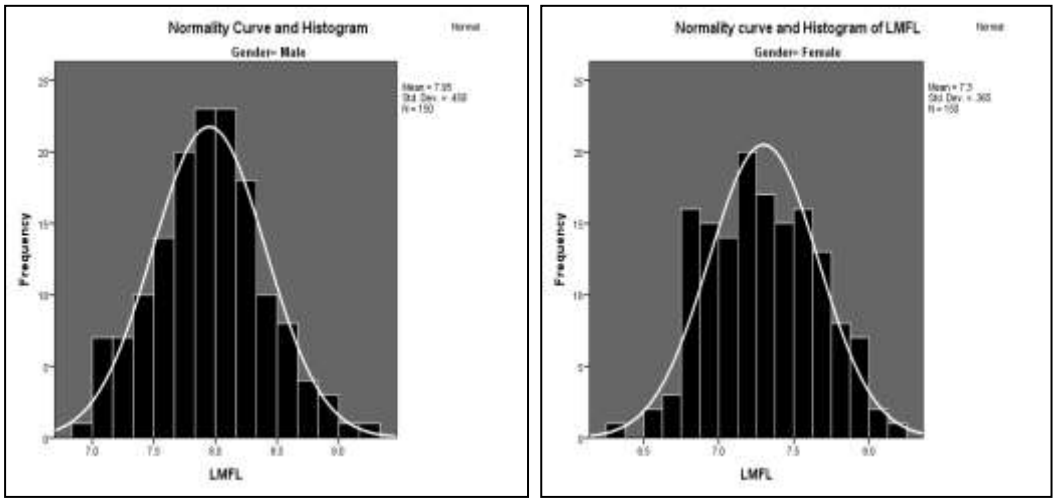

Figure VIII: Distribution pattern with normality curve of right middle finger length in male and female

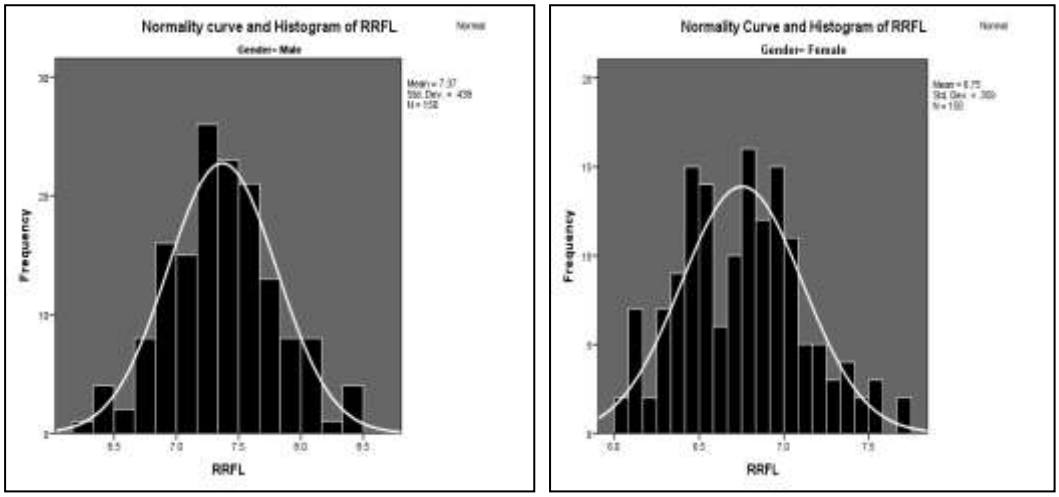

Figure IX: Distribution pattern with normality curve of left middle finger length in male and female

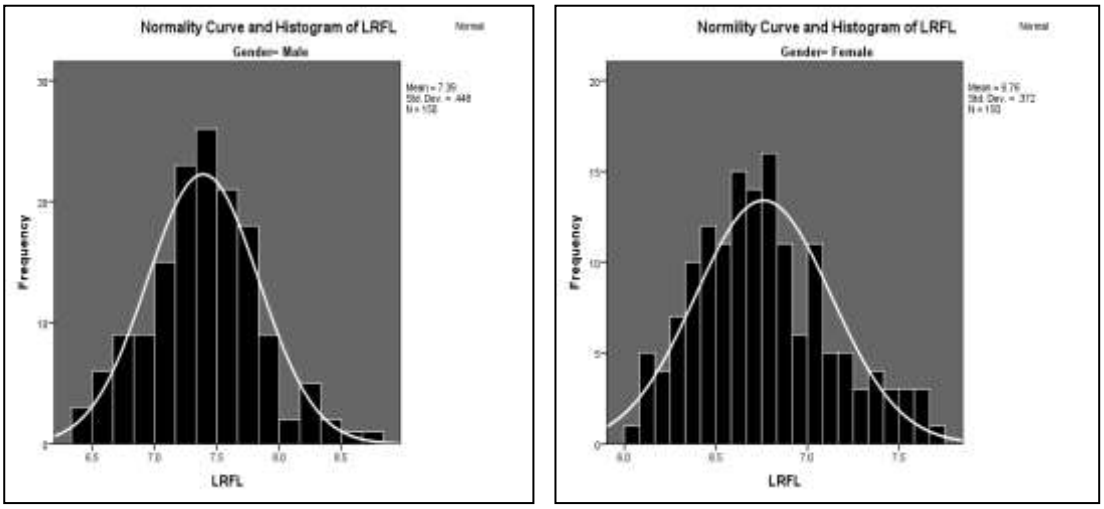

Figure X: Distribution pattern with normality curve of right ring finger length in male and female

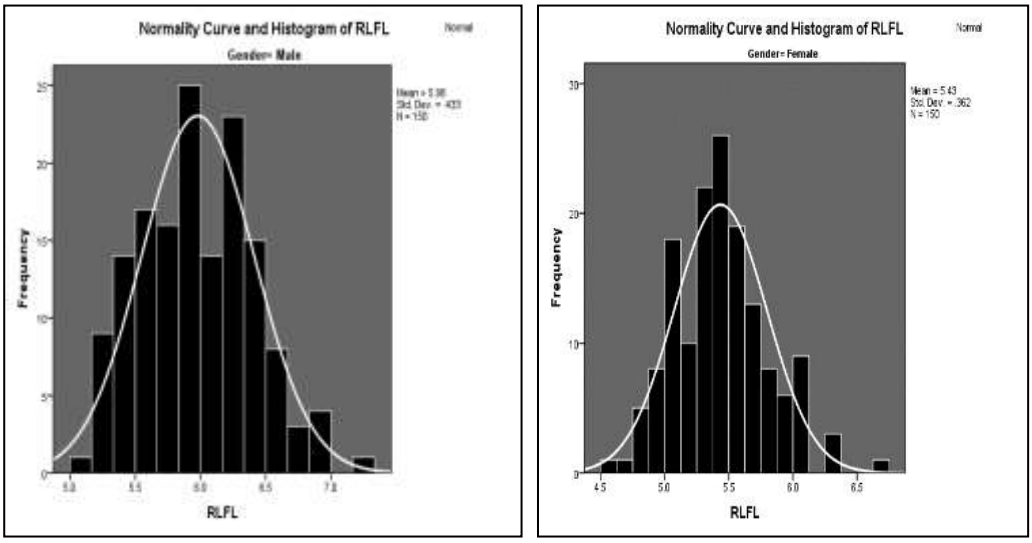

Figure XI: Distribution pattern with normality curve of left ring finger length in male and female

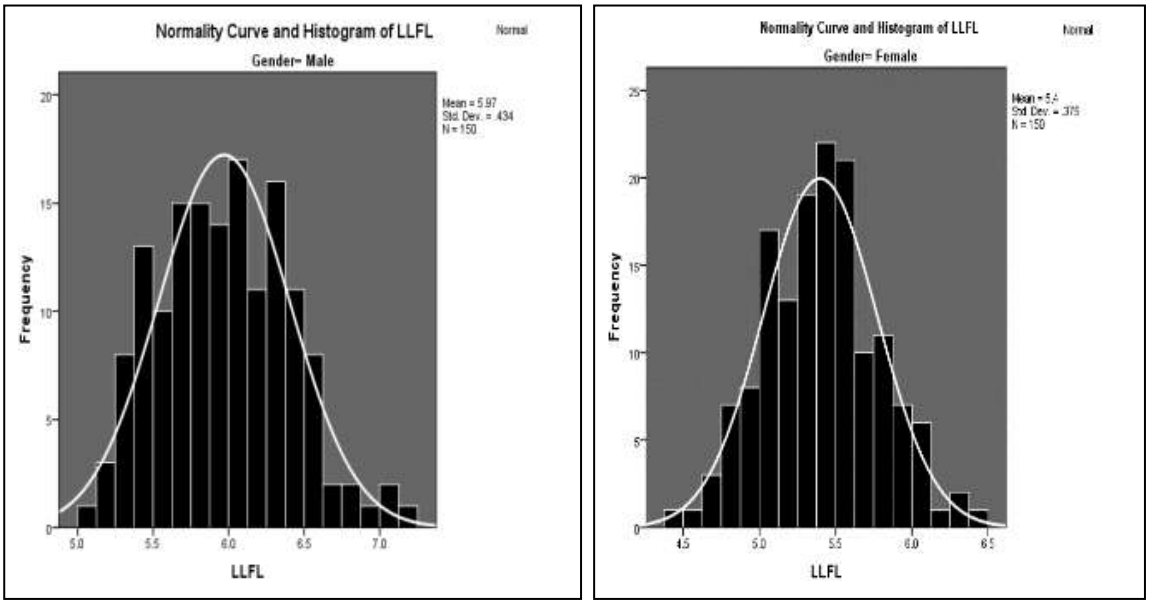

Figure XII: Distribution pattern with normality curve of right little finger length in male and female

Pearson's Correlation Coefficient

The Pearson's correlation coefficient between stature and hand measurements (hand length and finger length) for male and female are shown in table 5. The correlation data shows that there is highly significant positive correlation between stature and hand measurements (hand length and finger length), indicating the moderate relationship between stature and hand measurements (hand length and finger length) in both male and female. The Pearson's correlation coefficient (r) between stature and RHL, RTFL, RIFL, RMFL, RRFL and RLFL was found to be 0.656, 0.454, 0.642, 0.469, 0.591 and 0.513 respectively, in male. The Pearson's correlation coefficient (r) between stature and RHL, RTFL, RIFL, RMFL, RRFL and RLFL was found to be 0.578, 0.572, 0.576, 0.547, 0.468 and 0.433 respectively, in female. The Pearson's correlation coefficient (r) between stature and LHL, LTFL, LIFL, LMFL, LRFL and LLFL was found to be 0.636, 0.468, 0.580, 0.647, 0.603 and 0.498 respectively in male. The Pearson's correlation coefficient (r) between stature and LHL, LTFL, LIFL, LMFL, LRFL and LLFL was found to be 0.601, 0.459, 0.532, 0.535 and 0.454, and 0.435 respectively in female.

It was also observed that hand length was better correlated with stature than finger length. Among finger length RIFL and LMFL in both genders was better correlated with stature. It was also observed that correlation between hand length and stature was higher among male than female. In case of finger length it was also higher among male than female except for RTFL and RMFL.

Table 2: Correlation study among Variables

Parameters	Stature Male (n= 150)	Stature Female (n'= 150)
	r	R
Right hand length	0.656**	0.578**
Right thumb finger length	0.454**	0.572**
Right index finger length	0.642**	0.576**
Right middle finger length	0.469**	0.547**
Right ring finger length	0.591**	0.468**
Right little finger length	0.513**	0.433**
Left hand length	0.636**	0.601**
Left thumb finger length	0.468**	0.459**
Left index finger length	0.580**	0.532**
Left middle finger length	0.647**	0.535**
Left ring finger length	0.603**	0.454**
Left little finger length	0.498**	0.435**

Data are presented as correlation coefficient (r) between stature and hand and finger measurement in male and female. n= number of male, n'= number of female. ** p-value < 0.01 was considered as highly significant and * p-value<0.05 was considered as statistically significant.

Discussion

Estimation of an individual's stature is an important parameter in forensic examination and anthropological study, it helps to establish physical identity of an individual (IIayperuma et al., 2009). Various studies have been conducted on estimation of stature from the skeleton of human body such as forearm length measurement (Bidmos et al., 2010) foot dimension, femur, head circumference. Although varieties of methodology have been proposed to estimate stature from various bones, regression analysis has been proved to be the easiest and most reliable method (Mansur et al., 2014).

Most of the studies on estimation of stature from skeleton of human body were carried out in Nigerian population (Numan et al., 2013) Indian population and Thai population (Patel et al 2014). Therefore, the

present study was carried out to derive equation for stature estimation from hand and fingers length and also to determine the relationship between stature and hand measurements (hand and finger length) in both genders of medical students of KMCTH in Nepal. This equation can be used as alternative mean of stature calculation when direct calculation of stature is not possible due to various circumstances. Evaluation of present study findings with previous studies revealed several differences as well as similarities. 300 subjects were included in the present study out of which 150 were male and 150 were female. There were an equal number of male and female subjects for study which was similar to study done by Kanchan et al (2008). In study of Aboul- Hagag et al. (2011), Agrawal et al. (2013) and Ibegbu et al. (2013) the number of male and female was equal too. Stature, hand length and finger length were measured by standard anthropometric techniques among the subjects and statistical analysis was done. In contrast to present study Jasuja and Singh (2004), Isak (2010), Ahmed and Purkait (2011) measured the hand and finger length by the help of both anthropometric method as well as by ink hand print method. They reported that the difference between measurements done by anthropometric method and print method was insignificant. The present study was conducted among age group of 18-26 years unlike the study of Ibegbu et al. (2013) among the Nigerian school children which include the age group of 5-10 years, Laila et al. (2009) among the Bengali adult Muslim female that include the age group of 25-30 years. Similar age group of 18-26 years was selected for the study by Agrawal et al. (2013), Bardale et al. (2013), Chawla et al. (2013),slam et al. (2013).The mean stature of male was found to be 170.15 ± 6.27 cm and the mean stature of female was found to be 156.83±4.73 cm. The mean stature of male of present study was similar to Sir Lankans adults as shown by the study of Ilayperuma et al. (2009)32 and the study of Tang et al. (2012) among people of china but the mean stature of female in their study was higher than the present study. The mean stature of female of present study was similar to Bengali adult Muslim (Laila et al. 2009).The mean stature of both genders was comparatively higher than the present study in North Indian population (Jasuja and Singh 2004, Rastogi et al. 2009). Such difference in stature may be due to population variation which may be attributed to genetic and environmental factor.

In the present study the mean right and left hand length of male was 18.56 ± 0.87 cm and 18.63 ± 0.87 cm respectively. The mean right and left hand length of female was 17012 ± 0.73 cm and 17.12 ± 0.73 cm respectively. The mean hand length of both genders was comparatively higher than present study in North Indian population (Jasuja and Singh 2004), Upper Egyptian (Aboul Hagag et al., 2011). The mean hand length of both genders was lesser than present study in in Nigerian school children (Ibegbu et al. 2013), 44 this difference may be due to age difference of their and present study.

Analysis of genetically disparate population reveals clear pattern of sexual dimorphism with female consistently having smaller hand, proportionate to the stature than male (Saxsena 1984; Lundy and Feldsman 1987). The result of present study was in agreement to above statement. In present study, it was evident that there was highly significant ($p < 0.01$) gender difference (as shown in table 3) with male stature, hand length and finger length being larger than female. In study done by Habib and Kamal (2009), they reported significant sex difference in stature, hand length and phalange length with male being larger than female. Jasuja and Singh (2004), Ilayaperuma et al (2009), Numan et al (2013) also observed that mean value of stature and hand length was higher in male than in female which was consistent with present study. In contrast to the present study, Ibegbu et al. examined Nigerian school children of age group 5-10 years and demonstrated that male has shorter hand length than female which was contrast to the present study. Scientifically it is known that female child grows faster than male child and also the age of puberty begins 2 years later in male as compared to female which could indicate that female child have longer hand length than male child. In the present study finger length measurement also shows the statistically significant ($p<0.01$) sexual dimorphism with male finger length being larger than female. Kanchan et al (2008) also evaluated the difference in index and ring finger length between male and female in South Indian population; they reported that the mean value of index and ring finger length for both hands were significantly larger in male ($p\leq0.001$) than in female. Donborno et al (2008) examined Nigerian population and demonstrated that male index and ring finger length was significantly higher than female. Rastogi et al (2009) examined North Indian and South Indian population and demonstrated that middle finger length was significantly higher among male than female. These study support the finding of present study by demonstrating that even the smallest hand measurement (e.g. thumb length) are still quantifiably sexually dimorphic.

These sexually dimorphic finding in various above studies signifies that genetically male are taller than female. In the present study, there was no statistically significant ($p<0.05$) bilateral difference in the measurements of hand length and finger length in both genders except for the right hand length in male and thumb finger length in both genders but the difference were relatively small.

In the present study, it is evident that all the measurements hand length as well as finger length have a positive and highly significant correlation with the stature in both genders. Highly significant and positive correlation between the stature and hand measurements allowed the present study to calculate the regression equation separately for female and male which was supported by many previous studies. Jasuja and Singh also observed statistically significant correlation between stature and hand length and phalange length and concluded that stature could be estimated from their study parameters.

Habib and Kamal studied Egyptian subjects and found that hand length gave better prediction of stature than length of phalanges. In present study also hand length gave better correlation coefficient than the finger length which was also similar to the study done by Isak (2010) who reported that hand length has highest correlation coefficient than finger length in both genders. Although the present study finding was similar to those reported in earlier studies but the value of correlation coefficient differs from those reported in earlier studies. Similarly the equation derived for estimating stature from hand length and finger length of medical students of KMCTH differs from those presented by the previous studies who carried out their among different population. This observation could be attributed to population and ethnic difference between the present study and other earlier study which could be influenced by genetic and environmental factor.

It is evident that hand and finger length are also one of the best parameters to predict stature of individual. Therefore, if either of hand length, finger length and/or stature is known then other can be estimated and this fact may be practical use in Medico-legal investigation in Anthropometry.

Conclusion

Stature is an important indication when determining the partial identity of unidentified bodies of dismembered remains. The present study reveals that hand length and finger length can be used successfully to estimate stature of medical and dental students of KMCTH. The study shows that the stature, hand length and finger length were sexually dimorphic, in all the parameters, the male were significantly higher than the female. The study also highlighted that the bilateral variation was insignificant for most of the measurements except for the hand length in male and thumb finger length in both genders but the difference was relatively small. The study reveals that there exist a highly significant and positive correlation between stature and hand length and finger length in both genders indicating moderate relationship between these parameters.

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