

Original Research Article**CORRELATION OF FOREARM LENGTH WITH HEIGHT OF THE THARU INDIVIDUALS RESIDING IN NAWALPARASI DISTRICT OF NEPAL*****Deepak Chaudhary¹, Sanjay Kumar Yadav², Surendra Kumar Sah³**¹Department of Clinical Anatomy and Cell Biology, Karnali Academy of Health Sciences, Jumla Nepal.²Department of Anatomy, National Medical College, Birgunj, Nepal.³Department of Anatomy, Nobel Medical College, Biratnagar, NepalReceived Date: 5th-January-2026, Accept Date: 25th-April-2026, Published Date: 29th-June-2026**ABSTRACT****Background**

Biometric parameters such as face, fingerprints, length/ breadth of different body parts are necessarily used in modern world in the forensic sciences and in anthropology. Among these, finding stature for identification is the most primary parameter.

Objectives

The objectives of the study were to measure the height and forearm length of Tharu individuals and establish a correlation between these two parameters.

Methods

A descriptive study was done in 162 healthy male and 163 healthy female adult individuals of Tharu community through convenience sampling. Physically challenged and individuals having intercaste marriage known in previous generation were excluded. Forearm length and height of the individuals was measured and the data was analyzed using the R 4.4.1 package. Descriptive quantitative data was reported in Mean±SD. T-test was used to compare the data. Linear regression was used to predict the relation between height and forearm length

Results

The mean height was found to be 165.5±6.00 cm in male and 154.0±5.70 cm in female and 159.7± 8.21 cm in overall individuals. The mean forearm length was found to be 27.69±1.09 cm in male, 25.15±1.20 cm in female and 26.42± 1.71 cm in overall individuals. Regression equation for overall individuals was found as Height (Ht) = 51.46+ 4.1 X FAL cm and $r^2 = 0.7325$ where FAL= Forearm length and r^2 is the Co-efficient of Determination.

Conclusions

There exist relationships between height and forearm length and regression equation can be used in determining the height and forearm length in Tharu individuals.

Keywords: Anthropometry, Forearm length, Height



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INTRODUCTION

Identification of individual's identity by the help of different biometric parameters such as face, colour, voice, fingerprints, length/ breadth of different body parts has become necessity in modern world in the forensic sciences, anthropological areas. Among these parameters, finding stature for identification is the most primary parameter. This is particularly more important and helpful in cases of mutilated bodies of homicide, genocide or mass disasters during which its body remains are used to identify the body stature.

Multiple studies have described the correlation of forearm length [1], combined length of forearm and hand [2], upper extremity [3] with the individual's stature. Somatometry of hands have also been used to correlate the individuals height [4,5]. Significant studies are also seen correlating the foot length with the statures [6,7]. The lengths of tibia and ulna have also been used for height estimation [8,9]. These studies are correlated in the different sexes, region and ages. The formulation of multiplicative factors and regression equations are also developed according to different community, ages, sexes, ethnicity or on regional basis, which have shown significant correlation between individuals' stature with these parameters [4-9]. Body architecture and stature are also seen to have significant variation between different races [10].

Studies related to the correlation of height with forearm length are seen in other ethnicity or in group of individuals unspecified to any ethnicity but studies in Tharu tribes are not seen.

The aims and objectives of the study were to measure the height and forearm length of Tharu individuals and establish a correlation between these two parameters.

METHODS

A descriptive cross-sectional study was conducted in individuals of Tharu community from Sarawal Rural Municipality, Ward No.3 of Nawalparasi district of Nepal. Apparently healthy adult Individuals (as per history) consisting of 162 male and 163 female from Tharu community were selected for the study through convenience sampling. The minimum Sample Size was calculated as $(n = [Z^2 \times p(1-p)/e^2] / [1 + (Z^2 \times p \times (1-p)/e^2)N]) = 299.05$; Where n= Sample size, N=Population size (1350), p=Population

proportion (0.5), $Z=1.96$ at 95% confidence level and $e=$ margin of error (0.05). Adding 10% non-response rate, the target sample size was ~329. Individuals below 18 years; physically challenged individuals and individuals having intercaste marriage known in previous two or more generation were excluded. Individuals of known dwarfism and with forearm injury or surgery done previously were also excluded. The ethical clearance was taken from the Institutional Review Committee of Devdaha Medical College & Research Institute (IRC-DMCRI, Ref no: 579/078/079) with protocol approval number: 05/2022. The data was collected from September 2022- December 2022.

Right and left forearm length and height of the individuals was measured using Standard anthropological instruments. Stadiometer was used to measure the total body height up to the vertex of the skull in Frankfurt's plane on bare foot. Nonstretchable tape measure was used to measure the forearm length in a flexed elbow from the apex of the olecranon process up to the point middle of the ulnar and radial styloid process. The average length of right and left forearm length was taken for the data analysis. All the measurements were taken in 'cm'. To avoid interpersonal errors; a single person took all the measurements.

The data was analyzed using the **R 4.4.1 package**. Descriptive quantitative data was reported in Mean \pm SD. T-test was used to compare the data and correlation between quantitative data was obtained. Linear regression was used to predict the relation between height and forearm length.

RESULTS

The mean height for male individuals was found to be 165.5 \pm 6.00 cm with maximum height of 183cm and minimum height of 151.0 cm. The median for the data was found to be 165.0 cm

The mean height for female individuals was found to be 154.0 \pm 5.70 cm with maximum height reaching upto 164.5cm and minimum height of 135.0 cm. The median for the data was found to be 153.0 cm

The mean height for all individuals was found to be 159.7 \pm 8.21 cm with maximum height of 183 cm and minimum 135 cm. The median for the data was found to be 160 cm. It is illustrated in **Table (1) and Figure (1)**.

Table 1: Comparisons of different statistical data for height between male and female individuals.

Parameters	Minimum Height	1 st Quartile (Q ₁)	Median	Mean	3 rd Quartile (Q ₃)	Maximum Height	Standard Deviation (SD)
Male	151.0	161.4	165.0	165.5	168.5	183.0	6.00
Female	135.0	150.0	153.0	154.0	158.5	164.5	5.70
Overall	135.0	153.0	160.0	159.7	165.0	183.0	8.21

The mean forearm length for the male individuals was found to be 27.69 ± 1.09 cm with maximum length reaching 30 cm and minimum of being 25.50 cm. The median for the data was found to be 28.00 cm. The mean forearm length for female individual was found to be 25.15 ± 1.20 cm with maximum length reaching 28.30 cm and minimum of being 23 cm. The median for the data was 25.00 cm. The mean forearm length for all individual was found to be 26.42 ± 1.71 cm with maximum length reaching 30 cm and minimum of being 23 cm. The median for the data was found to be 26.50 cm. It is illustrated in Table-2 and Figure-2.

Table 2: Comparison of different statistical data for forearm length between male and female individuals.

Parameters	Minimum Forearm length	1 st Quartile (Q ₁)	Median	Mean	3 rd Quartile (Q ₃)	Maximum Forearm length	Standard Deviation (SD)
Male	25.50	27.00	28.00	27.69	28.30	30.00	1.09
Female	23.00	24.00	25.00	25.15	26.15	28.30	1.20
Overall	23.00	25.00	26.50	26.42	28.00	30.00	1.71

The linear regression equation for all individuals was found to be as; $Ht = 51.46 + 4.1x FAL$ with Standard Error of Estimate of 4.25 and Co-efficient of determination (r^2) as 0.7325. The same was; $Ht = 48.20 + 4.24x FAL$ for male with Standard Error of Estimate of 3.80 and Co-efficient of determination (r^2) 0.6018. For female it was found to be as; $Ht = 78.34 + 3.01x FAL$ with Standard Error of Estimate of 4.43 and Co-efficient of determination (r^2) as 0.4014. Figure (3) shows the regression plot and table (3) shows the correlation between the height and forearm length.

Table 3: Correlation between the height and Forearm length

	Linear Regression Equation	Standard Error of Estimate	Co-efficient of determination (r^2)	P-value
Overall	$Ht = 51.46 + 4.1x FAL$	4.25	0.7325	<0.01
Male	$Ht = 48.20 + 4.24x FAL$	3.80	0.6018	<0.01
Female	$Ht = 78.34 + 3.01x FAL$	4.43	0.4014	<0.01

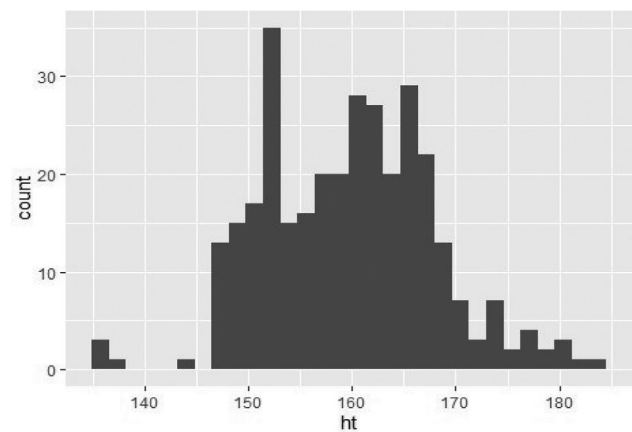


Figure 1: Histogram above showing the overall individuals count with their height.

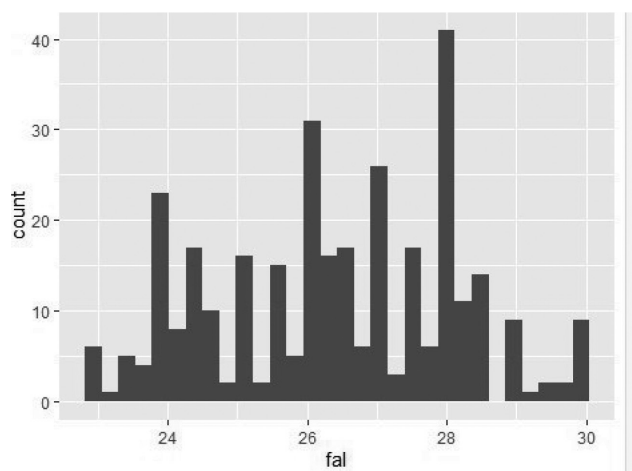


Figure 2: Histogram above showing the frequency of overall individuals' forearm length (FAL).

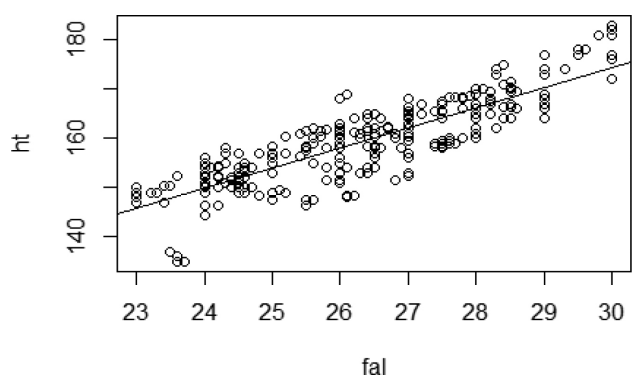


Figure 3: Regression plot for overall individuals above showing the correlation between height and forearm length where Height (Ht) = $51.46 + 4.1 \times FAL$ cm and $r^2 = 0.7325$

DISCUSSION

Anthropometric measures have been very significant in the investigation of individuals' identity. These are most crucial in the forensic sciences, anthropological sciences, mass disasters during natural calamities and wars. Differences in the anthropometric measures are also seen in different races and ethnicity [10, 11,

12]. Studies related to facial morphometry are also found which are used in correlation to determine the individual's age, height, races and ethnicity [10]. These facial morphometry are also used in determining the attractiveness [13] and reconstruction of the facial structures. Many of the anthropometric measures are associated with genetic disorders [14, 15].

Tharu are the indigenous tribe residing in the terai region of Nepal and adjacent part of India [16]. Few studies are seen in the anthropometry of Tharu tribes which are associated with cephalic indices [17] and nasal indices [18]. Studies related to the correlation of height with forearm length are seen in other races or are seen in group of individuals unspecified to any races but studies in Tharu tribes are not seen. As per the study done in Asian, Black and White men [19], the height of men in our studies was found to be 165.5 ± 6.00 cm which is less than the height of Asian (170.9), Black (178.1 cm) and White (176.3 cm) race. Similar was the case in female also having a mean height of 154.0 ± 5.70 cm being less but near to Asian women (157.7), as compared to Black (164.0 cm) and White (163.7) [19]. In another study done in eastern population of India (In Odisha), where overall average is not calculated, the maximum sample is found to be in the height range of 165-170 cm in male and 150-155cm in female [20], which is close to our study if we consider comparing our median of 165 cm and mean of 165.5 ± 6.0 cm in male and median of 153.0 cm and mean of 154.0 ± 5.7 cm in female. Similarly the average forearm length was 24.05 ± 0.943 cm in that height group [20] which is less than that of our study having a mean forearm length of 27.69 ± 1.09 cm in male and in female of that height group the average forearm length was 21.55 ± 1.62 cm which is again less than that of our study having a average forearm length of 25.15 ± 1.20 cm. The mean forearm length for male individual was more than that of the female being significantly different ($p < 0.01$).

Regression equation has been a very reliable method for estimating height from forearm length, or any other morphological parameters of the body such as foot length, arm length and so on. As we see the regression plot (Figure 3), the predicted height shows significant estimate for the overall individuals rather than for each gender. This might be attributed to the lower sample size while going gender wise.

LIMITATIONS OF THE STUDY

There may be undiagnosed and unapparent health issues affecting height, other confounders such as genetic variations and nutritional factors might affect the result, although we included only the Tharu race with no history of inter-caste marriage. This study is restricted only in Tharu individuals of a single community, thus limiting the generalization. Future research can utilize similar study in diverse population for the determination of height using forearm length.

CONCLUSIONS

We have described the relation between forearm length and height of adult Tharu individuals. The intercept and slope of the equation can be used in determining the height by measuring the forearm length. Such determination might be useful in conditions where height estimation may not be feasible (in resource limited conditions) or in forensic investigation of disfigured bodies where height cannot be directly measured, thus adding the identity.

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