ORIGINAL ARTICLE

# Study of Correlation of Femur Length and Stature in Living Persons

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**Abstract:**
*Introduction:* Natural height of a person is known as 'stature' (1). Height estimation from skeletal remains is a useful tool in forensic medicine and biological anthropology (2). Through numbers of research studiesacross the world; many multiplication factors and equations have been designed to know the stature of skeletal remains. Most commonlythe long bones are used for estimation of stature of an individual. Out of these, the lengths of lower limb bones giveconsistent and more accurate estimation of stature. *Objective:* The main objective of this study is to studythe length of lower limb bones particularly femur to reconstruct stature by multiplication factors and regression equations. *Material and Methods:* The present study comprised of 100 students of different colleges of Dadra Nagar Haveli within the age range of 21 to 30 years. Subjects were measured for the length of femur, in accordance with the standard measurement techniques recommended. All observations were recorded in centimetres (cm). *Results:* The correlation coefficients obtained were (r) of 0.5 and 0.64 for male and female femur respectively. The stature calculated from femur length as per regression equation is 171.89 with a standard deviation of 6.77 for males and 166.9 with standard deviation of 4.53for females. The stature calculated from femur length by using multiplication factor is 170.19 with a standard deviation of 7.98 for males and 165.5 with standard deviation of 4.97for females**.** *Conclusion:* Positive correlation is observed between femur, one of the long bones of the lower limb with the stature of the individual. Our study ended with new regression equation and multiplication factor to determine height of person from the length of a femur in living.
**Keywords:** Femur length, Stature, Height of person.

## Introduction:

In general, the term used for natural height of a person is known as 'stature' (1).This term is one of the prime characteristics of a person which helps in identification of individual. Height estimation from skeletal remains is a useful tool in forensic medicine and biological anthropology (2). Many clinical studies have concluded that height of a person is related to dimensions of other body part (3).In mass disasters like explosions, railway and aircraft accidents identification is difficult by routine methods and only part of body that can help in identification of skeleton as at least a part of it will be available (4).Estimation of stature is regarded as an important domain of medicolegal investigations for identification of unknown and mutilated skeletal remains. Through numbers of research across the world many multiplication factors and equations have been formed to know the stature of skeletal remains(5,6,7,8,9,10). Most importantly, out of these long bones are being used frequently. Out of these, the lengths of lower limb bones give more accurate estimation of height (11). This study is further pronouncing the use of length of lower limb bones particularly femur to reconstruct stature by multiplication factors and regression equations.

## Material and Methods:

For estimation of height, fundamental assumption is that the longer the bone, taller the person. So, length of the long bone of lower limb is directly related to stature of that individual. The present study comprised of 100 students of different colleges of Dadra Nagar Haveli within the age range of 21 to 30 years. The participants with any obvious congenital or acquired deformity of the lower limb, achondroplasia or any other congenital, nutritional, acquired or hereditary bony disease were excluded from the study to get non biased outcome. Equal number of male and female subjectswereselectedby applying inclusion and exclusion criteria. For this study approval of ethical committee was obtained from the NAMO Medical Education & Research Institute, Silvassa. Subjects were measured for the length of a femur, in accordance with the standard measurement techniques recommended. All observations were recorded in centimeters (cm). Each subject was measured for the following dimensions: - Stature (S): It was obtained a s

the vertical distance between the standing surface and the highest point on the head (vertex) when the subject was standing in the anatomical position, using anthropometer (stadiometer). The subjects were asked to stand barefoot and vertically close to a wall where stadiometer was mounted with the heels of their feet touching the stadiometer. The stadiometer was then pulled down to touch the vertex of the participants' heads, and the value was recorded as read from the stadiometer.Femur Length (FEML): It was measured when the subject was standing erect with the left leg placed slightly ahead of the right leg and the foot partly inverted to relax the muscles. For femur length, percutaneous femur length is taken, which is the distance between greater trochanter to the lateral condyle. The measurement was obtained as the distance from the upper most point on the greater trochanter to the lower most point palpable on the lateral femoral condyle, using rod compass (spreading calliper). Each measurement was repeated 3 times to alleviate bias and the mean value was recorded. The error was assessed for every anatomical parameter according to the standard method. The same procedure was followed to obtain per cutaneous length of both femurs of that individual. Basic parameters were noted like name, age, sex, height in cm, length of femur in cm in appropriate format. It was observed through review of literature that the 'femur length' is term used as a length of femur whereasthe term 'percutaneous femur length' is used when femur length is measured in situ. So, the terms 'femur length' and 'percutaneous femur length' are same. Regression formulae and multiplication factors were developed for various combinations to reach the best estimate possible. The regression formula is of type, Y=A+B(X); it is a simple regression equation, where Y= Height of individual to be estimated, A= Regression constant, B= Regression coefficient, X= Percutaneous length of femur.Here 'X' is the only independent variable. Multiplication factor for the individual long bones were calculated for each person and mean of all was calculated. The following equation was used to get the multiplication factor: K=H/L Where, H= Height, L = Length of femur, K= Constant multiplication factor which was specifically determined for individual long bone from the various data so obtained. After formulation of the regression formulae and multiplication factors we correlated them with actual height of 50 random males as well as females as show in diagram no 1 and 2 respectively. The data obtained was analysed using Microsoft Excel 2013 and SPSS. Bivariate analysis was used for correlation analysis to determine correlation between left and right percutaneous femur lengths with the height.The binary logistic was used to get equations for predicting sex using the parameters measured. Independent samples t-test was used to study the differences in the measured parameters between males and females as well as right and left femur lengths.

**Result:**

The study was conducted between the age group of 21 to 30 years; the mean ± SD age of sample population was 23.14 ± 1.61 years. Stature of the sample population studied ranged between a minimum of 152.4 cm and maximum of 193 cm with a mean ± SD being 171.6 ± 6.77 cm, for male and 166.5± 4.53 cm for females. Femur lengths of the sample population were compared on both sides. There is no statistically difference between right and left side femur length. The mean femur length in the subjects (combined right and left) was 44.15 ± 2.02 cm for males and 42.25± 2.02 cm for females.

Table 1: Comparison of the mean femur length of the two sides in males

| Length (cm) | | Male | | |
|---|---|---|---|---|
| | | Mean | ± SD | P value |
| Femur | Right | 44.4 | 2.03 | < 0.001 |
| | Left | 44 | 2.01 | < 0.001 |
| | Combined (Right+ Left) | 44.15 | 2.02 | < 0.001 |

Table 2: Comparison of the mean femur length of the two sides in females

| Length (cm) | | Female | | |
|---|---|---|---|---|
| | | Mean | ± SD | P value |
| Femur | Right | 42.4 | 2.03 | < 0.001 |
| | Left | 42.2 | 2.01 | < 0.001 |
| | Combined (Right + Left) | 42.25 | 2.02 | < 0.001 |

Table 3: Mean percutaneous femur lengths of the two sides and their p value in males

| Males | | | | | |
|---|---|---|---|---|---|
| Length (cm) | Right | | Left | | P value |
| | Mean | ± SD | Mean | ± SD | |
| Femur | 44.4 | 2.03 | 44 | 2.01 | 0.785 |

Table 4: Mean percutaneous femur lengths of the two sides and their p value in females

| Females | | | | | |
|---|---|---|---|---|---|
| Length (cm) | Right | | Left | | P value |
| | Mean | ± SD | Mean | ± SD | |
| Femur | 42.4 | 2.03 | 42.2 | 2.01 | 0.760 |

Table 5: Femur length in relation to height and sex

| Gender | Mean femur length (cm) | Mean height (cm) | Femur/height (%) | Correlation of coefficient 'r' |
|---|---|---|---|---|
| Male | 44.15 | 171.6 | 25.7% | 0.5 |
| Female | 42.25 | 166.5 | 25% | 0.64 |

Table 5 depicts regression analysis and correlation of the femur length with stature of the population sample studied. During study a positive correlation was observed between the stature and the femur length and the correlation was highly significant statistically ($p<0.001$).The correlation coefficients obtained were (r) of 0.5 and 0.64 for male and female femur respectively. This positive correlation coefficients indicate that length of femur of the human correlates directly with the height of individual, increase in the femur length represents increase in the height of the person.While these linear regressions both had strong linear correlation, and therefore are valid.It was interesting to compare the constants of this studyto other investigations of same character. Scatter plots were made to determine the regression equations for males and females, regression equations obtained showed a slope of 1.817and 2.564 for males and females respectively indicating that height estimation is different in males and females. These equations being; Height= 1.8172 femur +91.272 and Height = 2.5649 femur +56.989 for males and females respectively from this study. The regression for calculating the height from the femur was: Height = 2.610 femur + 44.201 and Height = 2.019 femur + 67.579 for males and females respectively, indicating that regression equations for males and females are different. Multiplication factor derived from the percutaneous femur lengths to calculate stature from the total population sample is 3.82 for male and 3.76 for female. The stature calculated from femur length as per regression equation is 171.89 with a standard deviation of 6.77 for males and 166.9 with standard deviation 4.53for the females. The stature calculated from femur length by using multiplication factor is 170.19 with a standard deviation of 7.98 for males and 165.5 with standard deviation 4.97for the females. The present study shows positive correlation between stature as measured by regression equations and multiplication factors with that of the actual height of a person. The regression equations when applied to a fresh sample of the different colleges, showed a mean difference between actual height and estimated height is less than 1 cm ($p>0.05$). Therefore, the derived regression equations are valid and applicable in Indian population, with little mean deviation.

Table 6: Similar types of results were obtained in study conducted by the following authors

| **Author** | **Equation for stature from femur** | **Mean** | **± SD** |
|---|---|---|---|
| Pearson 1899 [5] | Males: S=81.231+1.880(FEML) | 167.41 | 3.95 |
| Trotter and Gleser 1952 [9] | Males: S=61.41+2.38(FEML) | 170.51 | 5.00 |
| Singh and Sohal 1952 [12] | Multiplication factor 3.63 | 166.40 | 7.63 |
| Arifviqar et al, 2018 Regression equation [13] | Males: Y=A+B(X) S=39.05 + 2.95(FEML) | 173.89 | 6.77 |
| Arifviqar et al, 2018 Multiplication factor [13] | Males S = 3.80 x (FEML) | 174.19 | 7.98 |
| Present study Regression equation | Males: S=44.147+2.610 (FEML) Female: S= 42.149+2.019 (FEML) | 171.89<br>166.9 | 6.77<br>4.53 |
| Present study Multiplication factor | Male: S= 3.82× (FEML) Female: S= 3.76 × (FEML) | 170.19<br>165.5 | 7.98<br>4.97 |

**Discussion:**

Similar type of study was conducted by many authors across the world. Approximately similar type of results was observed by the authors, i.e., mean standard hight was more in male as compared to female. Following is the table, which shows the comparison of the different studies with the present study.

**Conclusion:**

Positive correlation is observed between femur length; one of the long bones of the lower limb with the stature of individual. Age and sex specific regression equation and multiplication factor are required for the accurate stature reconstruction. Our study ended with new regression equation and multiplication factor to determine height of person from the length of a femur, the same can be extrapolated to region of students of different colleges of this territory with fair degree of accuracy. Hopefully this study will help many people in calculating stature of the person in their respective field particularly medicolegal branches. Similar type of studies needs to be conducted in future to obtain universal equation and to minimize error for accurate measurement of stature.

**Conflict of Interest - Nil**

**Sources of Support- Nil**

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