CHAPTER II

REVIEW OF LITERATURES

2.1 Estimation of Stature

In the history of estimation of stature, Beddoe (1887) made an endeavour to estimate stature from femoral length of the older races of England using separate formulae for males and females as follows:

For males

\[ X = 4\left[ F - \frac{1}{8} (F - 13) - \frac{1}{8} (F - 13 - [F - 19]) \right] \]
\[ = 3 F + F - \frac{1}{2} (F - 13) - \frac{1}{2} [F - 13 - [F - 19]] \]
\[ = 3 F - 13 + \frac{1}{2} (F - 19). \]

For females

\[ X = 4\left[ F - \frac{1}{8} (F - 12) - \frac{1}{8} (F - 12 - [F - 17.5]) \right] \]
\[ = 3 F + F - \frac{1}{2} (F - 12) - \frac{1}{2} [F - 12 - [F - 17.5]] \]
\[ = 3 F - 12 + \frac{1}{2} (F - 17.5). \]
Where, $X =$ living stature

$F =$ femoral length in inches.

It was as back as in 1888 that Rollet published his work in a tabular form to estimate stature from lengths of long bones of humerus, radius, ulna, femur, tibia and fibula of 50 male and female French cadavers ranging in age between 24-99 years. Measurements were taken from the above mentioned long bones in the fresh state and ten months later in the dry state and observed a loss of 2 mm in an average. Of course, the reduction in the length was more comparatively in longer bones.

Later in 1892 and 1893, Manouvrier reassessed Rollet’s data but excluded data of those individuals whose ages were above sixty years of age at the time of death and considered only 24 males and 25 females for his study. His opinion was that taking into account of the bone length of the subject whose age is above sixty years at the time of death may result in the decrease of about 3 cm from the calculated stature.

However, Pearson (1899) was of the opinion that whatever shortening or reduction in the calculated stature of those over sixty years actually occurred due to the anterior stooping of the body which after death more or less takes a flat shape on the table. Thus, according to Pearson the senile stoop might not have any influenced effect on the estimation of stature, especially from long bones. As such, any shortening due to old age is not a marked phenomenon as reflected in the data of Rollet.
Thomas Dwight (1894) described two methods for estimation of stature from the skeletonised remains that is, anatomical and mathematical methods. The anatomical method involves simply putting the bones together reproducing the natural curves of the spine, making due allowance for the soft parts and measuring the length of the bone. The mathematical method is based on the proportion of the long bone length to the height of an individual. The latter may be used in two ways i.e., by formulating prediction equations and by computing multiplication factor (MF). The anatomical method is workable when the complete skeleton is available whereas the mathematical method can be applied even if a single bone is available.

In 1899, Pearson laid down certain basic rules for estimation of stature. The basic rules that are related to anthropology and forensic problems are -to find out mean, standard deviation and correlations of long bones in a extinct allied race as it is possible to measure and when the correlations are found to be high, fifty to hundred individuals are sufficient. For the first time, he calculated correlations using Rollet’s data and further applied mathematical method of Thomas Dwight for formulating sex specific regression equations for reconstruction of stature from a single bone as well as combination of more than one bone of the upper and lower limbs.

The use of multiplication factor (M.F) to estimate stature was developed by Pan (1924). The Multiplication factor was obtained as a proportion of a long bone to stature. Pan measured the maximum lengths for
humerus, radius, ulna, femur, tibia fibula and stature among 142 East Indian (Hindu) cadavers in wet state with cartilage for estimation of stature.

Trotter and Gleser (1952) studied the American whites and black Negroes for estimation of stature from long bones of humerus, femur, radius, ulna, tibia and fibula. They found that the proportion of long bones to stature was larger among the black Negroes than those of whites.

Charnalia (1961) took up the measurements of foot length, foot breadth and stature among eight different castes and tribes of Pondicherry. He formulated co-efficient of correlation of foot length and foot breadth with stature.

Athawale (1963) studied among 100 males of Maratha Harijans and allied castes group of Maharastra. He developed multiple regression equations using radius and ulna for estimation of stature.

Patel et al., (1964) conducted research work on the aspect of estimation of stature from tibial length and concluded that age factor is not important in formulating regression equations to estimate stature from long bones.

Genoves (1967) estimated stature from maximum lengths of humerus, radius, ulna, femur, tibia and fibula of 98 cadavers in the hospitals of Federal Districts of Mexico. He formulated regression equations for the above mentioned long bones. Among these long limb bones, femur and tibia show the best correlation with stature.
Kolte and Bansal (1974) also attempted to estimate stature from lengths of long bones of humerus, radius and ulna among 96 and 35 female adult cadavers of Marathwada region of Maharashtra. They derived simple regression equations for predicting stature from these upper extremities.

Sharma et al., (1978) used foot length and foot breadth to estimate stature among male Gaur Brahmins and found a high correlation co-efficient value with stature.

Mysorekar et al., (1982) measured humerus and radius lengths to estimate stature among Indians belonging to Maharashtra. They derived regression equations for each parameter and observed that correlation co-efficient is highly significant in each parameter with stature.

Shitai (1983) studied among 50 Han males of South China. Ten (10) regression equations were derived, out of which six were of single bones i.e., humerus, radius, ulna, femur, tibia and fibula. Humerus and radius, humerus and ulna, femur and fibula, femur and tibia were taken as combination.

Badkur (1985) conducted research work among 82 males and 62 females of Bhopal based on six long bones of upper and lower extremities viz., humerus, radius, ulna, femur, tibia and fibula. Multiplication factor as well as regression equations were developed to estimate stature under the study for both sexes.
Tiwary (1986) formulated multiplication factors as well as linear regression equations using upper arm length, radial length, ulnar length, hand length, foot length, femoral length, tibial length and fibular length among 175 male Brahmins and 190 male Rajputs of Ranikhet of Uttar Pradesh.

Anand (1990) formulated multiplication factors for estimation of stature among Rajputs and Brahmins of Garhwal of Uttar Pradesh using percutaneous measurements of upper and lower extremities viz., upper arm length, ulnar length, hand length, foot length, femur length, tibial length, humerus bi-epicondylar and femur bi-epicondylar diameters.

Nath and Krishan (1990) derived multiplication factors, linear and multiple regression equations for estimation of stature from upper and lower extremities that is, upper arm length, radial length, ulnar length, hand length, foot length, femur length, tibial length, humerus bi-epicondylar and femur bi-epicondylar diameters among Hindu Bania females of Delhi.

Amit et al., (1995) conducted to estimate stature from distal half of upper limb viz., forearm and hand of 200 healthy students (100=male and 100=female) of Subharti Medical College Meerut between 19-25 years of age. They formulated regression equations and multiplication factors separately for males and females. The regression equations and multiplication factors for right and left arms were not different. Furthermore, statistically, no significant differences were found in between right and left measurements.
Jain et al., (1996) developed multiplication factors to estimate stature using hand length, and foot length among 132 male Brahmins of Kumaon in the age group of 17 to 19 years.

Nath (1997) studied among 248 Jats of Churus of Rajasthan aged between 18 to 23 years. He formulated multiplication factors for estimation of stature on the basis of hand and foot lengths.

Mohanty (1998) observed that tibial length and stature in both sexes were highly significant. He conducted his work on prediction of height from percutaneous tibial length among Oriya males and females belonging at the age range of 20 to 77 years and developed simple regression equations for both sexes.

Momochand and Devi (1998) derived simple regression equations for male and female for reconstruction of stature from tibial length among 500 mongoloid groups from northeastern region of India in the ages between 21 to 85 years.

Sethi and Nath (1998) attempted to formulate regression equations and multiplication factors for stature estimation using percutaneous lengths of lower limb bones i.e., femur, tibia and fibula among the Punjabi females of Delhi and concluded that as tibial length exhibits the highest correlation (r=0.729), it is the best estimate of stature.
Odilia et al., (1999) carried out their research work among the frail elderly Hispanics living in the northeastern united state. They developed regression equations to estimate stature from knee-height of elderly and disabled subjects. They observed that the aging process does not affect the length of long bones such as bones of arms and legs unlike those of vertebral height.

Jain et al., (1999) estimated stature through percutaneous measurements of hand and foot lengths among female Jats of Delhi ranging in age from 17 to 20 years. They computed multiplication factors for hand and foot lengths and found that multiplication factor for hand length exhibited greater reliability than that of foot length.

Further work of Sethi and Nath (2000) among the Punjabi females of Delhi whose ages ranging from 17 to 39 years show that of the two parameters of hand length and foot length, the latter provides the best estimate of stature among Punjabi females of Delhi.

Devi and Nath (2001) studied on prediction of stature among male Meiteis of Manipur ranging in age from 18 to 40 years using hand, foot and facial measurements and observed that foot length exhibits the highest correlation (r = 0.650) with stature.

Sethi and Nath (2001) also conducted their research work among the Jain females of Delhi aged between 17 to 37 years. Measurements of upper
limb bone dimensions such as upper arm length, ulnar length and radial length were taken. All parameters are positively correlated with stature and among the parameters, ulnar length exhibits the highest co-efficient correlation \( r = 0.783 \) with stature.

Later, Jadav and Shah (2004) carried out on this similar aspect of study for estimation of stature among the medical students belonging in the age range of 17 to 22 years of various regions of Gujarat by measuring head length and stature and found positive correlation between head length and stature.

Jain and Nath (2004) estimated stature from four lower extremities viz., femur, tibia, fibula and foot lengths among the male and female Jains of Delhi ranging in age of 18 to 40 years for males and 17 to 40 years for females. The correlation values indicated that fibular length among males and tibial length among females provide the best estimate of stature. The greater reliability of regression equation than multiplication factor has also been revealed.

Jasuja and Singh (2004) have pointed out that no significant difference exists between hand length and palm print length and concluded that stature can be estimated from actual as well as print measurements. They formulated regression equations for estimation stature using hand and phalange lengths of male and female Jat Sikhs aged between 18 to 60 years of northern India.
Ozden et al., (2005) studied the orthopedically healthy adult patients of Turkey males and females, who were admitted to Osmangazi University, Medical faculty, Turkey. They estimated stature from left and right foot length and foot breadth. Foot length exhibited higher correlation than breadth.

Among the tribal communities of Manipur, Jibonkumar and Lilinchandra (2006) carried out their research work among the Kabui Naga tribe of Imphal valley in the age group of 18 to 45 years for estimation of stature using different facial measurements. They formulated linear regression equations and multiplication factors. Among the various facial measurements, bigonial breadth exhibits the highest correlation ($r = 0.365$) with stature.

Nath and Bhavan (2006) predicted stature from hand and foot lengths among Shia Muslim males and females of Delhi. The multiplication factors (MF) have revealed that the highest MF value for males is represented by hand length (8.49) and for females by foot length (6.71).

Bhavna and Nath (2007) further formulated multiplication factors and linear regression equations for estimation of stature from lower limb measurements of femur, tibia, fibula, foot length and foot breadth among male Shia Muslims of Delhi ranging in the age from 20 to 40 years. The highest correlation was exhibited by tibial length ($r = 0.765$).

Patel et al., (2007) conducted their research work based on the left feet of males and females of healthy medical students aged between 17 to 22 years
of various regions of Gujarat. They concluded that height could be more accurately predicted from foot measurement as compared to those of long bones during adolescence age as ossification and maturation in the foot occurs earlier than the long bones.

Jakhar et al., (2008) took anthropometric measurements of foot length independently on the left and right sides of each student ranging in age between 21 to 32 years at Pt. B.D. Sharma PGIMS, Rohtak, Haryana. They derived regression equations for estimation of stature and concluded that left foot length gives better prediction of stature as compared to that of right foot length.

Krishan (2008) predicted stature from cephalo-facial dimensions of adult male Gujjars ranging in age from 18 to 30 years of north India. It has been indicated that all cephalo-facial measurements are positively and significantly correlated with stature and regression formulae calculated for cephalic measurements give high degree of reliability and accuracy in estimating stature.

Nath and Sharma (2008) studied among the Ezhava Hindus of Kerala ranging in age from 20 to 45 years using hand and foot lengths. They observed that hand length exhibits higher correlation with stature as compared to foot length in both sexes.
Chikhalkar et al., (2009) also studied among the students ranging in the age in between 19 to 23 years of Grant Medical College and Sir JJ Group of Hospital who belonged to local population of Mumbai for estimating stature from hand length and foot length. They suggested that the regression equations developed from the data of these students can not be applied to other Indian population groups.

Fatmah (2009) measured knee height, arm span and sitting height of Indonesian Javanese elderly people for estimation of stature. He formulated linear regression equations for each parameter with stature. He highlighted that in general, elderly male had bigger average knee height as compared to elderly female in all age groups. In his finding, the arm span was the most accurate predictor in estimating height. He also suggested that aging was associated with decreased mean stature, weight, arm span and sitting height, but does not affect the mean value of knee height.

Ilayperuma et al., (2009) worked on the aspect of prediction of stature based on hand lengths of both sides among medical students belonging at the age range between 20 to 23 years of the Faculty of Medicine, University of Rahuna, Galle, Sri Lanka. The results indicated that there was no bilateral variation in the comparison of hand length in between both sides.

Mondal et al., (2009) measured right and left ulnar lengths for estimation of stature among males in Burdwan district and adjacent areas of
West Bengal. The higher correlation co-efficient was found in right ulnar length as compared to left ulnar length.

Duyar and Pelin (2010) derived regression formula based on ulnar length for stature estimation among the Turkish population. They stressed that formulae used for estimating stature based on long bones should be population-specific.

Hossain et al., (2010) formulated multiplication factors using hand length and hand breadth of both sides for estimation of stature among the Christian Garo tribal females aged between 25 to 35 years who live in Dhaka city and Sylhet district of Bangladesh. They found positive correlation between hand length, hand breadth and stature.

Ilayperuma (2010) again conducted his research work on the prediction of stature using cranial dimensions among the medical students aged between 20 to 23 years of the Faculty of Medicine, University of Rahuna, Galle, Sri Lanka. Correlation co-efficient between stature and each cranial dimension was found to be positively correlated.

Singh and Singh (2011) undertook research work among the male Manipuri Muslims of Manipur at the age group of 18 to 70 years inhabiting in four valley districts of Manipur viz. Imphal west, Imphal east, Thoubal and Bishnupur districts. They derived regression equations and multiplication factors for estimation of stature using lower and upper extremity dimensions.
The higher correlation co-efficient was found in the dimensions of lower extremities than those of upper extremity.

Krishan et al., (2012) formulated regression equations and multiplication factors for stature estimation from hand and foot dimensions among the Rajput population of Himachal Pradesh. They confirmed that the stature estimation is more accurate and reliable with regression analysis than any other measure.

Mansur et al., (2012) derived regression equations for estimation of stature using foot length among the adult Nepalese students aged between 17 to 25 years of Kathmandu University school of Medical Sciences, Nepal. They found positive correlation between foot length and stature.

Natthamon et al., (2012) undertook their research work among the adult Thais ranging in the age group of 25 to 27 years using upper and lower extremities measurements. They found that upper extremity dimensions were more accurate among males, but unlike that of males, lower extremity dimensions show better estimate in predicting stature in case of females.

Chandravadiya at el., (2013) estimated stature from percutaneous tibial length among 210 students (110= males and 100=females) ranging in age between 18 to 23 years of the Department of anatomy, Government medical college, Bhavnagar, Gujarat and observed that the correlation of tibial length with stature for males (0.836) was higher than females (0.690).