

**“A STUDY ON STATURE ESTIMATION FROM  
HAND AND FOOT LENGTHS IN ADULT  
SUBJECTS OF BELGAUM REGION”**

**REG. NO. BB0110001**

**Dissertation  
submitted to the  
KLE University, Belgaum, Karnataka**

**In Partial Fulfillment  
of the requirements for the degree of**

**MASTERS DEGREE**

**in**

**ANATOMY**

**DEPARTMENT OF ANATOMY,  
JAWAHARLAL NEHRU MEDICAL COLLEGE,  
NEHRU NAGAR, BELGAUM – 590 010, KARNATAKA**

**APRIL 2013**

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**ENDORSEMENT**

This is to certify that the dissertation entitled  
**“A STUDY ON STATURE ESTIMATION FROM HAND  
AND FOOT LENGTHS IN ADULT SUBJECTS OF  
BELGAUM REGION ”** is a bonafide research work done by  
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### LIST OF ABBREVIATIONS USED

cms	Centimeters
M	Male
F	Female
LHL	Left Hand Length
RHL	Right Hand Length
LFL	Left Foot Length
RFL	Right Foot Length
S	Stature
SD	Standard deviation
SE	Standard Error
SEE	Standard Error of Estimate
Sig.	Significance
r	Correlation coefficient
BGT	Both Genders Together
i.e.	That is
t	Student test 't'
df	Degrees of freedom
R	Multiple correlation coefficient
Sr.No.	Serial Number
e.g.	For example
etc.	Etcetera
NGO's	Non Governmental Organisations

**ABSTRACT****BACKGROUND:**

Stature is one among the numerous data for identification of an individual, hence occupies a unique position in medicolegal cases and in the anthropological research areas. Thus assessment of height from different parts of the body is an area of interest to anthropologists, anatomists and forensic experts.

**OBJECTIVES:**

1. To assess hand length, foot length and stature.
2. To study the relationship between hand length, foot length and stature.

**METHODOLOGY:**

A cross sectional study was carried out on 100 males and 100 females belonging to the Belgaum region. The individuals of both the sexes aged between 18 years to 25 years were included in the study. The stature (height), hand length and foot length of both the sides of the individuals were measured. The stature was measured as vertical distance from vertex to the floor in mid-sagittal plane with the help of stadiometer. The hand length and foot length were measured with the help of sliding calipers and spreading calipers respectively.

### **RESULTS:**

The statistical analysis showed the correlations between stature and various parameters studied in males and females and ,were found to be statistically significant. The highest correlation coefficient was obtained between right hand length and stature (0.753) and lowest for left foot length and stature (0.700) among males. Similarly, in females, the highest correlation coefficient was obtained between right hand length stature (0.661) and lowest for right foot length (0.529). Linear and multiple regression equations for stature estimation were calculated separately for males and females.

### **INTERPRETATION AND CONCLUSIONS:**

It can be concluded that both hand length and foot length can be used to estimate stature in Belgaum region population. But the highest correlation coefficient between hand length and stature among males, females and in both genders (total sample) with lowest standard error of estimate, indicates that hand length provides highest reliability and accuracy in estimating stature in Belgaum region population.

### **KEY WORDS:**

Stature; Hand length; Foot length; Calipers; Stadiometer; Correlation; Regression.

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### INTRODUCTION

Stature is a major indicator of body size and bone length. It is a measurement of head, neck, trunk and extremities in general. Specific segment lengths are used in studies of growth and maturation of the body as well as in diagnosis of dysmorphology<sup>1</sup>.

Stature is also one of the numerous data for identification and occupies relatively a unique position in medical jurisprudence and in the anthropological research field<sup>2</sup>.

Anthropology is the science which deals with comparative study of man, as a physical and cultural being. It has two main branches – social anthropology and physical anthropology<sup>3</sup>. Social anthropology deals with the study of man as a cultural being<sup>3</sup>. Physical anthropology has been defined as the study of man's biological behaviour in time and space<sup>4</sup>.

It is a fact that no two persons are ever alike in all their measurable characters. Every individual tends to undergo change in varying degrees from birth till death, both in health and disease. Hence persons living under different conditions, and members of different ethnic groups and the offspring of unions between them, frequently present with interesting differences in bodily form and proportions<sup>5</sup>.

Anthropometry provides scientific methods and techniques for taking various measurements for observations of the living and their skeleton. Anthropometry represents the typical and traditional tool of physical anthropology<sup>4</sup>. Anthropometry is conveniently subdivided into the sections like somatometry and osteometry. Somatometry deals with

the overall measurement of body in the living and in the cadaver. Osteometry deals with the measurement of the skeleton and its parts<sup>5</sup>.

When a complete dead body is found, stature determination is rather an easy task but in cases where only some parts of the body are available, the determination of stature of an individual from skeletal material or from the mutilated or from amputated limbs or from parts of limbs, has obvious significance in the personal identification in the events of murders, accidents or natural disasters as required in forensic identification analysis<sup>2</sup>.

Till date most of the workers on stature estimation have used the length of bones such as femur, tibia, humerus, radius etc<sup>2</sup>. But, not much of studies have been done for the estimation of stature from hand and foot lengths in the Belgaum region. Hence the study was taken to fill this lacuna.

Accordingly, for the said purpose, a study on the hand and foot length of 200 adult subjects (100 males and 100 females) was carried out to estimate stature status of these individuals hailing from the Belgaum region.

This study looks into the possibility of estimation of stature from hand length and foot length in adult subjects of Belgaum region. Stadiometer (Anthropometer) was used to measure height of an individual. Sliding calipers was used to measure hand length and spreading calipers was used to measure foot length of an individual. The measurements of hand length and foot length were taken from limbs of both the sides of the body of an individual. Then correlation and coefficients between their anthropometric measurements were calculated. Independent linear regression equations to calculate the stature were

obtained for each of the independent variables like hand length and foot length. And effectiveness of these regression equations were analysed.

### OBJECTIVES

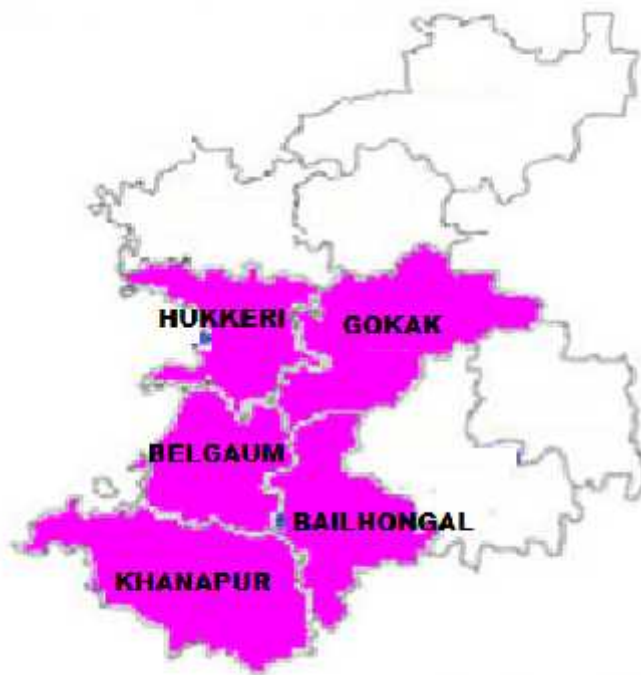
1. To assess hand length, foot length and stature.
2. To study the relationship between hand length, foot length and stature.

### INTRODUCTION TO THE STUDY POPULATION

Belgaum is the divisional headquarter of North Karnataka. The ancient name of Belgaum was Venugram, meaning Bamboo village. It is also called Malnad Pradesh. Belgaum is situated in the northwestern parts of Karnataka and lies in the border of two states, Maharashtra and Goa on the western ghats<sup>6</sup>.

Belgaum district has been divided into 10 talukas for administrative purpose. In our study Belgaum region includes five randomly selected talukas in Belgaum district as shown in the figure 1. The names of talukas are Belgaum, Hukkeri, Gokak, Bailhongal and Khanapur.

**Figure 1:** Map of Belgaum region (shown in pink colour)



Belgaum comes under the Bayaluseeme region of Karnataka. This city was built in the 12<sup>th</sup> century AD by Ratta dynasty. Belgaum city is located at 15.87° North, 74.5° East and is known for its pleasant climate all round the year. It is the commercial hub and divisional headquarter of North Karnataka, standing second to Bangalore in terms of overall exports in the state. The city is also known as “Bread basket / Rice bowl ” of North Karnataka<sup>7</sup>.

### THE HISTORY OF ANTHROPOMETRY

The word ‘Anthropometry’ was first used in the 17<sup>th</sup> century by German physician Johann Sigismund Elsholtz (August 26, 1623 – February 28, 1688). In 1654, he published ‘Anthropometria’, an early study of anthropometry. This book was written for the benefit of artists and astrologers, as well for the students of medicine and physiognomy<sup>8</sup>.



Johann Sigismund Elsholtz

Pierre Paul Broca (28 June, 1824 – 9 July, 1880) was a French physician, surgeon, anatomist and anthropologist. Broca was a pioneer in the study of physical anthropology.

## REVIEW OF LITERATURE

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In 1859, he founded the Society of Anthropology of Paris. Also he founded the Journal of Revue d'anthropologie in 1872 and the Institute of anthropology in 1876. He advanced the science of cranial anthropometry by developing many new types of measuring instruments (craniometers) and also numerical indices <sup>9</sup>.



Pierre Paul Broca

Alphonse Bertillon (April 24, 1853 – February 13, 1914) was a French police officer and biometrics researcher who created anthropometry, an identification system based on physical measurements. Anthropometry was the first scientific system used by police to identify criminals. Before that time, criminals could only be identified based on unreliable eyewitness accounts. The method was eventually supplemented by fingerprinting <sup>10</sup>.



Alphonse Bertillon

## REVIEW OF LITERATURE

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The work of standardizing the anthropometric techniques was continued by Garson and Reed under the auspices of the British Association for the Advancement of Science. The German Congress in 1912 approved the 'International Agreement for Unification of Measurements on the Living Subjects'. These two agreements are of fundamental importance to all students of anthropometry. They have been modified in the light of further scientific developments <sup>4</sup>.

In 1932, the International Committee for standardization of Anthropological Techniques was established in London attended by delegates coming from 20 different countries. The Committee ventured to suggest that a standardized anatomical nomenclature be used in definition, and best instruments be used for such specified purposes. It laid stress on defining various measurements required for specific purposes i.e., for living or dead material. It also emphasized the importance of the study of the comparative human anatomy as well as the correlation of observations on the living, cadavers and skeletal materials. The work of this committee is still continuing <sup>4</sup>.

In 1960 at the VI International Congress of Anthropological and Ethnological Sciences held at Paris, it was decided to form a Coordinating Committee for Standardization in Anthropometry. The committee decided to review the various hand-books of anthropometry in use and suggested methods to eliminate the divergence. Also it was asked to list the fundamental anthropometric measurements for racial studies. The committee presented a report at the VII International Congress at Moscow and is still continuing its work <sup>4</sup>.

Many physical anthropologists prepared guidelines suited to their specialized work. Chopra (1958) devised 'pelvimeter' for orientation and measurements of the

innominate bone. The search for new avenues continues. Anthropometrists working in different laboratories of the world on varied topics are continuously devising new measurements and new instruments such as roentgen graphic and photographic methods<sup>4</sup>.

### SUBDIVISIONS OF ANTHROPOMETRY

Anthropometry can be subdivided in to the following sections <sup>4</sup>:

- 1) Craniometry: Measurement of the skeletal brain cavity and face.
- 2) Cephalometry: Measurement of head and face in living and in cadaver.
- 3) Somatometry: Measurement of living body including head and face.
- 4) Osteometry: Measurement of long and short skeletal bones.

### MODERN ANTHROPOMETRY AND BIOMETRICS

Anthropometric studies today are conducted to investigate the evolutionary and significant differences in body proportion between populations whose ancestors lived in different environments. Human populations exhibit climatic variation patterns similar to those of other large-bodied mammals. Accordingly, Bergmann's rule states that, individuals in cold climates will tend to be larger than the ones in warm climates, and also Allen's rule states that, individuals in cold climates will tend to have shorter, stubbier limbs than those in warm climates.

On a micro evolutionary level, anthropologists use anthropometric variation to reconstruct small-scale population history. For instance John Relethford's studies of early 20th-century anthropometric data from Ireland show that the geographical patterning of body proportions still exhibits traces of the invasions by the English and Norse

communities centuries ago. Scientists working for private companies and government agencies conduct anthropometric studies to determine a range of sizes for clothing and other items. Measurements of the foot are used in the manufacture and sale of footwear measurement devices (e.g. the Brannock Device) or to determine the detailed dimensions of the foot for custom manufacture.

Today anthropometry can be performed with three-dimensional scanners. A global collaborative study to examine the uses of three-dimensional scanners for health care was launched in March 2007. The Body Benchmark Study will investigate the use of three-dimensional scanners to calculate volumes and segmental volumes of an individual body scan. The aim is to establish whether the Body Volume Index has the potential to be used as a long-term computer based anthropometric measurement for health care <sup>11</sup>.

### ANATOMY OF THE HAND

The hand consists of articulated bones made up of carpus, metacarpus and phalanges. The carpus consists of 8 carpal bones arranged in two rows. In radial (lateral) to ulnar (medial) order, the scaphoid, lunate, triquetrum and pisiform make up the proximal row, and the trapezium, trapezoid, capitate and hamate make up the distal row. The pisiform articulates with the palmar surface of the triquetrum, and is thus separated from the other carpal bones, all of which articulate with their neighbours. The other three proximal bones form an arch which is proximally convex, and which articulates with the radius and articular disc of the distal radio-ulnar joint <sup>12</sup>.

The distal row bones articulate with the proximal row bones by midcarpal joint. The carpal bones of each row articulate with each other by intercarpal joints. Carpal bones are cartilaginous at birth, although ossification may have started in the capitate and hamate. Each carpal bone is ossified from one centre, capitate first, and pisiform last<sup>12</sup>.

The metacarpus consists of five metacarpal bones, conventionally numbered in radio-ulnar order. These are miniature long bones, with a distal head, shaft and expanded base. The rounded heads articulate with the proximal phalanges<sup>12</sup>. The base of first metacarpal articulates with saddle shaped distal articular surface of the trapezium. The bases of other metacarpals articulate with the carpal bones of distal row<sup>13</sup>. The first metacarpal bone of the thumb is the shortest and most mobile<sup>14</sup>.

Each of the five metacarpal bones is related to one digit:

- metacarpal I is related to the thumb;
- metacarpals II to V are related to the index, middle, ring, and little fingers, respectively<sup>15</sup>

There are 14 phalanges, three in each finger, two in the thumb. Each phalanx has a base, a shaft (body), and distally, a head. The base of each proximal phalanx articulates with the head of the related metacarpal bone. The head of each distal phalanx is nonarticular and flattened into a crescent-shaped palmar tuberosity<sup>15</sup>.

### ANATOMY OF THE FOOT

The bones of the foot are the tarsal bones, the metatarsals, and the phalanges. The tarsal bones are arranged in a proximal group and a distal group with an intermediate bone between the two groups on the medial side of the foot. The proximal group consists of two large bones, the talus and the calcaneus. The intermediate tarsal bone on the medial side of the foot is the navicular. From lateral to medial, the distal group of tarsal bones consists of :

- the cuboid
- three cuneiforms - the lateral, intermediate and medial cuneiform bones<sup>15</sup>

There are five metatarsals in the foot, numbered I to V from medial to lateral. Metatarsal I, associated with the great toe, is shortest and thickest. The second is the longest. Each metatarsal has a head at the distal end, an elongate shaft in the middle, and a proximal base. The head of each metatarsal articulates with the proximal phalanx of a toe and the base articulates with one or more of the distal group of tarsal bones. The plantar surface of the head of metatarsal I also articulates with two sesamoid bones. The sides of the bases of metatarsals II to V also articulate with each other. The lateral side of the base of metatarsal V has a prominent tuberosity<sup>15</sup>. The phalanges are the bones of the toes. Each toe has three phalanges (proximal, middle, and distal), except for the great toe, which has only two (proximal and distal). Each phalanx consists of a base, a shaft, and a distal head:

- the base of each proximal phalanx articulates with the head of the related

metatarsal;

- the head of each distal phalanx is nonarticular and flattened into a crescent-shaped plantar tuberosity<sup>15</sup>

### EMBRYOLOGY OF HAND AND FOOT

Limb development begins with the activation of a group of mesenchymal cells in the lateral mesoderm. Homeobox genes regulate patterning in the formation of the limbs. The limb buds form deep to a thick band of ectoderm. Toward the end of the fourth week, the limb buds first appear as elevations of the ventrolateral body wall. The upper limb buds are visible by day 26 or 27, and the lower limb buds appear 1 or 2 days later. Each limb bud consists of a mass of mesenchyme covered by ectoderm. The mesenchyme is derived from the somatic layer of lateral mesoderm<sup>16</sup>.

The limb buds elongate by proliferation of the mesenchyme. The upper limb buds appear disproportionately low on the embryo's trunk because of the early development of the cranial half of the embryo. The earliest stages of limb development are alike for the upper and lower limbs. Because of their form and function, there are many distinct differences between the development of the hand and foot. The upper limb buds develop opposite the caudal cervical segments, and the lower limb buds form opposite the lumbar and upper sacral segments<sup>16</sup>.

By the end of the sixth week, mesenchymal tissue in the handplates has condensed to form digital rays. These mesenchymal condensations outline the pattern of the digits or fingers. During the seventh week, similar condensations of mesenchyme

form digital rays and toes in the footplates. As the tissue breakdown progresses, separate digits (fingers and toes) are formed by the end of the eighth week. Programmed cell death (apoptosis) is responsible for the tissue breakdown in the interdigital regions and it is probably mediated by bone morphogenetic proteins<sup>16</sup>.

### STATURE

Stature is defined as height of body in standing position. It is made up of head height, vertebral column length, lower extremity length and foot height. The head height is the basio-bregmatic length, vertebral column length is from C2 to S1 vertebrae, lower extremity length is the combination of the morphological length of femur and tibia and the foot height is the talo-calcaneal height<sup>17</sup>. Stature is a major indicator of body size and of the bone length. Specific segment lengths are use in studies of growth and maturation of body as well as in diagnosis of dysmorphology<sup>1</sup>.

If the body has been dismembered, the approximate stature may be determined by:

(1) The length from the tip of middle finger to the tip of the opposite middle finger, when arms are fully extended closely equals the height.

(2) Twice the length of one arm, with 30cm added for two clavicles 4cm for sternum, equals the height.

(3) The length from the vertex to the symphysis pubis is roughly half of the

stature.

(4) The length from the sternal notch to symphysis pubis multiplied by 3.3 gives the stature.

(5) The length of forearm measured from the tip of olecranon process to tip of the middle finger is equal to 5/19 of the stature.

(6) The height of head measured by the vertical distance from the top of the head to the tip of the chin is about one seventh of total height.

(7) The length of vertebral column is 35% of the height.

(8) The length of the entire skeleton and add 2.5 cm to 4 cm for the thickness of the soft parts<sup>18</sup>.

### **FACTORS MODIFYING STATURE**

Maximum height of a person is attained after the age of puberty, i.e. by 18-21 years of age. For all practical purpose stature at 18 years of age is accepted as adult stature, as median increment ranges from 0.8 cm in males to 0.6 cm in females from 18-30 years age. Stature decreases progressively after the age of 30 years at the rate of 0.06 cms/year. It can be counted by thinning of intervertebral discs and some stooping posture as a result of decreased tone of para-spinal muscles. Males are constitutionally taller than females and an association of Y chromosome with increased stature is well documented<sup>17</sup>.

Other factors modifying stature are race, geographical locations, climatic conditions, genetic disorders, nutritional status, stress, illness, living conditions and psychosocial circumstances. In addition, stature is maximum in morning and decreases by 1.5-2.0 cm by the end of the day. Stature increases by 2-3 cm on lying down due to relaxation of muscles and joints<sup>17</sup>.

### IDENTIFICATION

Identification is the determination of the individuality of a person based on certain physical characteristics, i.e. exact fixation of personality. Identification is necessary in :

- (1) Living persons,
- (2) Recently dead persons,
- (3) Decomposed bodies,
- (4) Mutilated bodies, and
- (5) Skeleton<sup>18</sup>.

Identification can be made based on name, age, sex, height (stature), general development, complexion, external peculiarities, fingerprints, footprints and anthropometric measurements<sup>18</sup>.

Police officers many times cannot accept as accurate or do not have eyewitness of height estimates for suspects in crime scene investigations. If present, footprints, either of

the bare foot or more commonly as shoeprints, provide an opportunity for estimating height as one characteristic, helping to identify or eliminate a suspect. Foot length displays a biological correlation with height that suggests the latter might be estimated from footprints or shoeprints when such evidence provides an investigator the best or only opportunity to gauge that aspect of a suspect's physical description<sup>19</sup>.

### THE REVIEW OF PREVIOUS WORKS

In 1902, Mac Donell conducted the first study in that century on a sample of 3000 male prisoners to know the relationship between height and foot length. The majority of them were English and Welsh prisoners. He recognized that population variation might complicate the relationship between foot length and height<sup>19</sup>.

In 1952, studies on the estimation of stature from the skeletal remains or from mutilated limbs, mostly of the long bones have been reported by Trotter and Glesser<sup>20</sup>.

In 1960, Bhargava and Kher conducted an anthropometric study in the population of Bhils of Dhar district of Madhya Pradesh. They collected anthropometric data of foot length and foot breadth. They determined the foot index which was found to be  $37.42 \pm 0.22$ . But they did not correlate the measurements of foot length and foot breadth with the stature<sup>21</sup>.

In 1961, V. M. Charnalia studied the foot length, foot breadth and stature of 541 males belonging to 8 different castes and tribes of Pondicherry. He found positive correlation between foot length and foot breadth which was statistically significant(0.63).

## REVIEW OF LITERATURE

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Stature had a high correlation with foot length (0.46) than with foot breadth (0.33). But he did not derive regression equation to calculate stature from foot length and foot breadth<sup>22</sup>.

In 1966, Das R studied the morphology of foot in 76 adult males and 105 females of Hira caste of Assam by using contour method<sup>23</sup>.

Rutishauser (1968) measured height and foot length in 683 African children aged 6 years or under in three groups of different ethnic origin. 60 were of Bantu, 328 of Nilotic and 295 of Nilohamitic origin. The correlation coefficients for the data of all three groups were similar (0.90-0.98). A highly significant ( $P < 0.001$ ) degree of association between height and foot length was found in three groups of different ethnic origin. The author developed regression equations for estimation of stature from foot length in children from birth to 6 years age group<sup>24</sup>.

Anandi Pal (1971) conducted a study of foot by contour method on 71 individuals (39 males and 32 females) of Onge tribe of Andaman. The author measured the foot breadth and foot length of both the feet. But he did not correlate the foot measurements and stature<sup>25</sup>.

Kate BR and Majumdar RD (1976) conducted a study to estimate stature from femur and humerus by regression and autometry. The regression formulae differed statistically in both sexes in femur and humerus<sup>26</sup>.

Qamra SR, Indar J and Deodhar SD (1980) measured height, foot length and foot

breadth of 1015 healthy adults between 14 to 32 years of age to develop methods for the reconstruction of height from foot measurements. They found good correlation of height with both foot length (male:  $r = 0.69$  and female:  $r = 0.70$ ) and foot breadth (male:  $r = 0.42$  and female:  $r = 0.47$ )<sup>27</sup>.

Saxena SK, Jeyasingh P, Gupta AK and Gupta CD (1981) conducted a cephalometric study on males aged between 25-30 years in Uttar Pradesh. They derived a regression equation between head length and height. The correlation coefficient between head length and height was 0.204<sup>28</sup>.

Bhatnagar DP, Thapar SP and Batish MK (1984) conducted a study on somatometry of the hand for identification of personal height in 100 normal healthy Punjabi males of age group 19 and 25 years. They measured stature, hand length and hand breadth on both the sides. They found bilateral symmetry in the measurements of hand length and hand breadth indicating insignificant variations. They also computed regression equations for the estimation of stature from somatometry of hand<sup>29</sup>.

Saxena SK (1984) conducted a study on 100 Nigerian adult male medical students of the Jos Medical School, Nigeria, between the age group of 20-30 years. The results shown that there were significant correlations between the stature of an individual, hand length, hand breadth and sole length. They also derived regression formulae to estimate stature from them<sup>30</sup>.

Constandse-Westermann TS, Blok ML and Newell RR (1985) conducted a study on long bone length and stature in Western European Mesolithic skeletons. They derived

equations for the estimation of stature from the sample of long bones of Western European Mesolithic skeletons. A systemic difference was observed between the stature estimation from the distal parts of the extremities and those from the proximal parts<sup>31</sup>.

Robbins LM (1986) collected foot prints and foot outlines of 500 subjects including both males and females ranging in age from 3-79 years. Each subject was weighed and the stature was measured. There was a strong positive correlation between stature and foot print or foot outline. The author concluded that either of the foot could be used to calculate stature<sup>32</sup>.

Attalah NL and Marshall WA (1986) conducted longitudinal studies for the estimation of stature from anthropometric and programmetric measurements of the limb segments including the foot sample. Multiple regression analysis was used to extract 38 programmetric and 36 anthropometric equations giving the most likely estimated value for stature together with the residual standard deviation from which confidence limits were calculated<sup>33</sup>.

Galloway A (1988) conducted a study on 550 Caucasian individuals from southern Arizona in older age group. Their stature was measured and subjects were asked to report their maximal height information in feet and inches, in a questionnaire. All the participants were the volunteers in long term bone mineral monitoring study. The author concluded that, the loss of height appears to commence from the age of 45 year and the average rate of loss was relatively rapid at 0.16 cm per year. The author also suggested the correlation factor for his study was 0.16 (age-45 year), subtracted from the maximum

height<sup>34</sup>.

Philip TA (1988) studied the footprints and foot outlines of 306 males between the age of 20-32 years to predict the stature. The stature to foot size index was calculated as ratio by the formula: Ratio index = Maximum toe length\*100/Stature<sup>35</sup>.

Abdel-Malek AE et al. (1990) conducted a study on 166 normal individuals (males and females together) from different colleges of Assiut in upper Egypt. Each subject has been studied for measurement of stature, hand length and hand breadth. The authors found close relationship between stature and hand measurements in both sexes and in both sides with significant correlations between each of them<sup>1</sup>.

Giles E and Vallandigham PH (1991) studied the correlation between foot length, shoe length and height using the database of US army personnel. The study included 6682 males and 1330 females. They found significant correlation of 0.678 for males and 0.693 for females for foot length and height. The authors concluded that the correlation of shoe length and height was lesser than foot length<sup>19</sup>.

Jasuja OP, Singh J and Jain M (1991) collected anthropometric data from 256 adult male Jat Sikhs from different villages Patiala district of Punjab. The measurements of stature, foot length, foot breadth, shoe length and shoe breadth were taken. The correlation between stature and these measurements were positive and highly significant at the 0.001 level. The correlation coefficients were higher in case of foot measurements compared to shoe measurements. The correlation coefficients have been observed to be higher in length measurements than in breadth measurements of foot and shoe. The

authors derived multiplication factors from these measurements to calculate stature from the foot and shoe measurements. Multiplication factors from length measurements result in less error than those of breadth measurements<sup>36</sup>.

Meadows L and Jantz RL (1992) derived formulae for the estimation of stature from metacarpal lengths. Stature was regressed on the basis of metacarpal length to derive equations. For males correlations ranged from 0.565 to 0.828 and standard errors ranged from 4.68 to 5.96. For females correlations ranged from 0.61 to 0.79 and standard errors ranged from 4.78 to 5.98<sup>37</sup>.

Jasuja OP and Manjula (1993) found a technique to estimate stature from the stride length of an individual in normal walk. Stride length was measured as a straight distance between the most backward points on the heels of two consecutive foot prints. Four to five steps were obtained from each walking pattern of an individual to minimize the chances of abnormal walk. The author found positive and statistically significant ( $P < 0.01$ ) linear correlation between stature and stride length<sup>38</sup>.

Jason DR and Taylor K (1995) calculated stature from the length of cervical, thoracic and lumbar segments of the spine in American whites and blacks from more than 3000 autopsies performed over fourteen years. Separate measurements were taken of the vertebral segments along with anterior surface of spine. Regression formulae were calculated for each segment. Standard errors of estimate (SEE) ranged from 2.60 to 7.11. The authors stated that the method would be useful for estimating the stature in severely burnt cases or mutilated bodies<sup>39</sup>.

Ousley S (1995) states that forensic stature estimation is generally less precise than Trotter and Glesser's stature estimation. But forensic stature is the only stature available in a missing person. So forensic stature estimation is considered as more accurate than Trotter and Glesser's stature estimation for forensic cases<sup>40</sup>.

Chiba M and Terazawa K (1998) estimated stature from somatometry of skull in 124 Japanese cadavers. The correlation coefficient of stature for various parameters of the skull ranged from between 0.32 to 0.53<sup>41</sup>.

Momanchand A and Devi M (1999) studied the relationship between statures of different persons and their inter-acromial length. The authors stated that regression equation formulae obtained from the study can be used to estimate stature when mutilated upper parts of the trunks are available<sup>42</sup>.

Rani M, Tyagi AK, Verma SK and Kohli A (1999-2000) conducted a study on 300 young and healthy students in the age of group of 18-22 years in the schools and colleges of Delhi. The percutaneous length of tibia of both sides was measured separately. Independent linear regression equations were derived for the purpose of stature reconstruction. It was concluded that these regression equations can be used with reasonable degree of accuracy for estimation of stature<sup>43</sup>.

Nath S and Chug D (2001) derived regression equations to estimate stature from hand and foot lengths among male and female Brahmins of Sundernagar, Himachal Pradesh<sup>44</sup>.

Monoj JI et al (2001) measured statures of 104 healthy adults from Spain. They took antero-posterior tele-radiograph of the right lower limb and the right upper limb of every subject in order to measure the lengths from femur, tibia, fibula, humerus, radius and ulna. Pearson's regression formulae were obtained for both limbs. In males femur was found to be the most accurate predictor of stature with correlation coefficient (r) of 0.851 and in females tibia was found to be the most accurate predictor of stature with correlation coefficient (r) of 0.876<sup>45</sup>.

Radoinova D, Tenekedjiev K and Yordanov Y (2002) developed a new regression procedure for predicting the stature from the length of limb long bones taking into consideration of sex and age related changes. The stature and length of humerus were measured in 416 forensic cases of adult Bulgarians (286 males and 130 females). The measurements of bones and stature were made on cadavers before autopsy. Stature regression analysis was performed for each of the three bones, as well as for a combination of humerus and tibia. Regression parameters, standard deviations and standard errors of their regression were calculated. These methods provided better and more reliable results of stature estimation for the Bulgarian population than other formulae<sup>46</sup>.

Ozaslan et al (2003) conducted a study on 203 adult male and 108 adult female Turks to correlate the various lengths of lower extremity (like trochanteric length, thigh length, leg length and foot length) and stature which showed a good correlation between lower limb measurements and stature. They suggested that estimation of living height could be made possible using various measurements of lower extremity like leg length

and foot length<sup>47</sup>.

O P Jasuja and G Singh (2004) conducted a study to estimate stature from hand and phalange length in 60 adult Jat Sikhs (30 male and 30 female) of age group ranging from 18 to 60 years. Stature, hand length and phalange length of all fingers of both the hands were measured. In addition to this inked palm prints were also obtained to measure hand length and phalangeal length from print. Statistically significant correlations were present between the stature and these measurements. The regression equations have been derived from these measurements and concluded that stature can be estimated from actual as well as print measurements with a standard error of estimate ranging from 4.033 to 4.820 cm in case of males and 5.061 to 5.127 cm in case of females<sup>48</sup>.

Jadhav HR and Shah GV (2004) conducted a study to estimate personal height from the length of head in 727 medical students of age group ranging between 17 to 22 years belonging to Gujarat region. They found positive correlation between head length and height with correlation coefficient of +0.53<sup>49</sup>.

Hilmi Ozden et al (2004) conducted a study on stature and sex estimation using foot and shoe dimensions in a group of 569 individuals composed of 294 males and 275 females in Turkey. They found highest correlation coefficient in length measurements than width measurements. A notable difference between males and females existed with regard to both right and left foot and shoe length and width averages and shoe sizes ( $P < 0.001$ )<sup>50</sup>.

Rani M, Tyagi AK, Verma SK and Kohli A (2004) conducted a study to estimate

stature from percutaneous measurements of leg in the department of Forensic Medicine, University College of Medical sciences, Delhi. They stated that there exists a direct relationship between stature and leg length<sup>51</sup>.

Sanli SG et al (2005) conducted a study to estimate the relationship between hand length, foot length and stature using multiple linear regression analyses based on a sample of male and female adult Turks residing in Adana. Measurements of hand length, foot length and stature were taken from 155 adult Turks (80 males and 75 females) aged 17-23 years. The participants were students of the Medical Faculty of Cukorva University. In males the correlation between stature and hand length ( $r = 0.722$ ) was better than between stature and foot length ( $r = 0.716$ ). In females the correlation between stature and hand length ( $r = 0.709$ ) was better than between stature and foot length ( $r = 0.699$ ). In both genders together the correlation 'r' between stature and foot length ( $r = 0.881$ ) was better than that between stature and hand length ( $r = 0.873$ ). The multiple regression model for both genders together group was found to be the best model among all the regression models<sup>52</sup>.

Fessler DM et al. (2005) examined the data available from three previous anthropometric studies (Davis 1990, Parham et al 1992 and Ozaslan et al 2003) and foot tracings of Steggard collection at US National Museum of Health and Medicine. The authors concluded that although varying in degree, across population, proportionate to stature, female foot length was smaller than male foot length. They also found sex differences in the ratio between foot length and stature<sup>53</sup>.

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Oommen A, Mainker A and Oommen T (2005) conducted a study on 100 normal subjects (50 males and 50 females) without any physical deformities or previous history of trauma to the hands or feet. Their hand length and foot length were measured using standard points. The results showed a highly significant correlation ( $P < 0.0001$ ) between hand length and foot length on both sides and in both sexes. The results were also indicating that if the hand length is known, foot length can be predicted and if the foot length is known hand length can be predicted and vice versa<sup>54</sup>.

Manoonpol C et al (2005) conducted a study on estimation of stature from foot size in Thai people aged 18-25 years. The study was done to determine the relationship between the size of the foot and height of the body. They derived at the equation to calculate stature as, ideal height =  $82.234 + 3.430$  (foot length)<sup>55</sup>.

Celbis O and Agritmis H (2006) attempted to access sex and stature from long bones of forearm using deceased forensic cases in Istanbul, Turkey. The sample was consisting of 80 male and 47 female corpses at the age 18-63 years (mean age 36 years for males and 30 years for females) without any physical deformities. All measurements were taken before the autopsy during the postmortem period without rigor mortis. Regression analysis was used in stature estimation from these two bones. The study showed a high correlation between the stature and bone lengths (for ulna and radius in male:  $r = 0.62, 0.64$  and in female:  $r = 0.76, 0.85$  respectively)<sup>56</sup>.

Oberoi DV et al (2006) measured maximum foot print length and height of 200 students (100 males and 100 females) of age group between 18-26 years belonging to

## REVIEW OF LITERATURE

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Mangalore, Karnataka. Predictive equations using linear regression were then derived separately for males, females and for the combined data with the purpose of estimating the height only when the subject's foot print length is known. The correlation coefficient ( $r$ ) of 0.698 in males, 0.738 in females and 0.848 in the combined data was obtained between the height and foot print length of the subjects. The standard foot print length was 23.55 cms. The accuracy of sex determination was reported to be 80%<sup>57</sup>.

Krishan K and Sharma A (2006) conducted a study on Rajputs of Himachal Pradesh to examine the relationship between stature and dimensions of hand and foot. The study population was consisting of 123 males and 123 females with the age group between 17-20 years. All the measurements were in high correlation with the stature ( $P < 0.01$ ). In males the highest correlation ( $r = 0.741$ ) was between left foot length and stature whereas, in females the highest correlation ( $r = 0.739$ ) was between right foot length and stature. Regression equations were derived separately for each sex, each side and for each measurement of hand and foot. They concluded that the estimation of stature can be done by using dimensions of hands and feet with good reliability<sup>58</sup>.

Agnihotri AK et al (2007) conducted a study to develop a relationship between foot length and stature using linear and curvilinear regression models. Measurements of foot length and stature were taken from 250 medical students (125 males and 125 females) aged between 18-30 years. General multiple regression model was highly significant ( $P < 0.001$ ) and validated with highest values for the coefficients of determination 0.769 and multiple correlation coefficient 0.877. Right foot length, sex and

age were explained for about 77% variations in stature<sup>2</sup>.

Patel SM, Shah GV and Patel SV (2007) estimated foot length and height of 502 students (278 male and 224 female) belonging to various regions of Gujarat with the age group between 17 to 22 years. The left foot was selected for measurement as per recommendation of the international agreement for paired measurements, declared at Geneva. A good correlation of height was observed with foot length and it was statistically significant. The correlation coefficient between height and foot length was +0.65 in males and +0.80 in females<sup>59</sup>.

Bhavna and Nath S (2007) conducted a study to estimate stature on the basis of measurements of lower limb in 503 male Shia Muslims of Delhi in the age range of 20 to 40 years. Each subject was measured for stature, femur length, tibial length, fibular length, foot length and foot breadth. Among the five lower extremity measurements foot breadth exhibited the lowest value of standard deviation (0.63) while the highest value was observed for femur length (1.96). It was observed that tibial length exhibited the overall highest value of correlation ( $r = 0.765$ ) with stature followed by fibular length and femur length while foot breadth exhibited the least correlation ( $r = 0.383$ ) with stature. They concluded that regression equations provide greater reliability in estimated stature<sup>60</sup>.

Krishan K and Vij K (2007) studied diurnal variation of stature in three adults and one child. The measurements of stature were recorded four times in a day for 56 days. Significant diurnal variation was observed in all the subjects and stature begins to

decrease immediately after rising in the morning. They also observed very rapid decrease in stature occurring within first two hours of the day and further loss continues throughout the day in small amounts. A maximum mean daytime loss of stature up to 2.81 cm was observed<sup>61</sup>.

Kanchan T et al (2008) examined the relationship between stature and foot dimensions among Gujjars, a North Indian endogamous group. Stature, foot length and foot breadth of 200 subjects comprising 100 males and 100 females were measured. Statistical analysis indicated that the bilateral variation was insignificant for all the measurements except foot breadth in males ( $P < 0.01$ ). Sex differences were found to be highly significant for all the measurements ( $P < 0.01$ ). Highest correlation was seen for left foot length ( $r = 0.764$ ) among males and right foot breadth ( $r = 0.799$ ) in females. Prediction of stature was found to be most accurate by multiple regression analysis<sup>62</sup>.

Sen J and Ghosh S (2008) attempted to understand the relationship between stature and feet dimensions among Rajbanshi male and female individuals of North Bengal, India. Measurements of stature, foot length and foot breadth were recorded from 350 adult Rajbanshi and 100 adult Meche individuals (age range: 18-50 years) residing in Darjeeling district of West Bengal. Using ANOVA, significant differences ( $P < 0.05$ ) was found in stature, foot length and foot breadth between sexes. Stature, foot length and foot breadth were positively and significantly correlated with each other ( $P < 0.01$ ). The higher correlation coefficient between stature and foot length over that stature pointed to the fact that foot length, rather than foot breadth, was more accurate in estimating stature.

Prediction of stature was more accurate by using step-wise multiple regression<sup>63</sup>.

Krishan K (2008) attempted to reconstruct stature in a sample of 2080 bilateral foot prints and foot outlines collected from 1040 adult male Gujjars of North India ranging in age from 18 to 30 years. Bilateral foot prints and foot outlines of each individual were measured. Significant and positive correlation coefficients were existed between stature and various measurements of footprint and foot outline ( $P < 0.001$  and  $0.01$ ). The highest correlation coefficients were shown by the toe length measurements ( $0.82-0.87$ ) indicating a close relationship between the stature and these measurements<sup>64</sup>.

Dayal MR, Steyn M and Kuykendall KL (2008) conducted a study to derive regression formulae for the estimation of total skeletal height and thereafter to predict stature in South African whites using long bone lengths. The sample comprised of 98 white males and 71 white female skeletons from Raymond A Dart collection of human skeletons and Pretoria bone collection. For each individual, total skeletal height and maximum bone lengths were measured. Femur measurements demonstrated the highest correlations with total skeletal height. All correlations involving the femur were 0.92 or above in males, while those in females were 0.93 or above. They concluded that regression formulae using combinations of bone lengths were showing much better correlation with total skeletal height than those using bones<sup>65</sup>.

Ilayperuma I, Nanayakkara BG and Palahepitiya KN (2008) carried out a study to investigate the relationship between personal stature and foot length among a group of male and female Sri Lankan adults and to derive a regression formula between the foot

length and height of an individual. A total of 210 medical students with an age of 20-23 years were included in the study. The differences of foot length between the genders were found to be highly significant. A positive correlation between height and foot length was observed in both sexes and it was statistically significant. Regression equation for stature estimation was formulated using the foot lengths for both sexes. It was concluded that foot length provides an accurate and reliable means in estimating the stature of an unknown individual<sup>66</sup>.

Laila SZH et al (2009) conducted a study on anthropometric measurements of the hand length and to correlate it with stature of Bengali adult Muslim females. Study was done on 150 adult Muslim females with an age group of 25-30 years. The study showed significant ( $P < 0.001$ ) positive correlation between the stature and hand lengths. The multiplication factor of right side was 9.51 and left side was 9.28<sup>67</sup>.

Ilayperuma I, Nanayakkara G and Palahepitiya N (2009) predicted personal stature based on hand length in 258 medical students (140 males and 118 females) of the Faculty of Ruhuna, University of Ruhuna, Galle, Sri Lanka. The age of subjects ranged from 20-23 years. The study showed correlation coefficients of +0.58 for males and +0.59 for females which were highly significant. The formulated regression equation formulae were valid for the age group of the study population<sup>68</sup>.

Deopa D et al (2010) carried out a study to estimate the relationship between foot length and stature using simple linear regression analysis based on a sample of male and female adults of Uttarakhand region. Measurements of foot length and stature were taken

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from 125 adults (62 males and 63 females) aged between 17-24 years. The correlation coefficients of height for foot length in males, females and for both genders together were 0.75, 0.66 and 0.86 respectively. These values were highly significant ( $P < 0.001$ )<sup>69</sup>.

Kanchan T et al (2010) conducted a study to estimate stature from foot length using universal regression formula in North Indian population. The study was conducted on 100 Gujjars with an age group of 18-32 years residing in Patiala district of Punjab, North India. The stature and foot length on both sides were significantly greater ( $P < 0.001$ ) in males when compared with females. The right and left foot length showed no significant differences between sides ( $P = 0.77$  in males and  $P = 0.60$  in females). It was concluded that foot length was well correlated to the stature in Gujjar community of North India<sup>70</sup>.

**METHODOLOGY**

The sources of data were hand length, foot length and stature (height) measurements taken from 200 subjects (100 males and 100 females) of adults of Belgaum region.

**Study design:** Cross sectional type of study

**Duration:** 1 year.

**Sample size:** A study was conducted on 200 adult subjects (100 males and 100 females) of age group between 18-25 years belonging to Belgaum region.

Sample size was calculated by using the following formula:

$$n = \left[ \frac{Z_{\alpha} + Z_{\beta}}{r} \sqrt{1-r^2} \right]^2 + 2$$

where, n = sample size,

r = correlation coefficient,

$Z_{\alpha}$  and  $Z_{\beta}$  are values of standard normal variants .

To calculate the sample size the value of 'r' is taken from previously done studies. Accordingly the 'r' value for males taken as 0.406 and 'r' value for females taken as 0.512. And to calculate the sample size with the power of 95%,  $\beta$  value is take as 0.05 and  $\alpha$  value taken as 0.05. Hence  $Z_{\alpha} = 1.96$  and  $Z_{\beta} = 1.96$ .

By substituting these values in the above formula, sample size came up to 90 males and 55 females i.e., total 145. But to get the accurate results, total sample size of 200 (100 males and 100 females) was taken for the study.

### **Method of collection of data:**

Permission was obtained from the authorities of several colleges, establishments, NGO's, etc, coming under Belgaum region to conduct this study. The project was submitted to Independent Ethical Committee of Jawaharlal Nehru Medical College, Belgaum. After getting the approval letter from Independent Ethics Committee the study was started. Measurements of male and female adult subjects were taken by selecting them from several colleges, institutions and NGO's coming under randomly selected five talukas in Belgaum region containing 40 adult subjects (20 males and 20 females) from each taluka. Informed written consent forms were taken from the subjects.

The following measurements were taken from subjects.

**1) Stature:** It is measured as vertical distance from vertex (the highest point on the top of head) to the floor in mid-sagittal plane with subject standing barefooted, on an even floor and the head being oriented in the Frankfurt's plane. With the help of Stadiometer (Anthropometer) stature was measured<sup>5</sup>.

**2) Hand length:** The hand is laid flat on a table. It is the straight distance from mid- point of a line connecting the styloid processes of radius and ulna to the most anterior projection of the skin of the middle finger. It was measured with the help of Sliding calipers<sup>5</sup>.

**3) Foot length:** It is the straight distance from the most posteriorly projecting point on the heel (akropodion) to the tip of the most anteriorly projecting toe (pterion), when the subject is standing erect. It was measured with the help of Spreading calipers<sup>5</sup>.

The measurements of hand length and foot length were taken from the limbs of both sides of the body.

### **Inclusion criteria:**

1. Healthy and normal adult subjects of age group 18-25 years.
2. All adults belonging to belgaum region. In my study belgaum region includes five randomly selected taluks out of ten taluks in belgaum district. The names of the taluks are Belgaum, Hukkeri, Gokak, Bailhongal and Khanapur.

### **Exclusion Criteria:**

1. Subjects with any musculoskeletal deformity like kyphosis, scoliosis, poliomyelitis, trauma etc. which will affect the normal measurements of stature, hand and foot length.
2. Measurements excluded if any nail extending over the end of toe and other fingers.

### **Materials used :**

- 1) Anthropometer (Stadiometer)
- 2) Spreading calipers
- 3) Sliding calipers

### Analysis Plan:

Mean and standard deviation of each anthropometric measurements was calculated. Then correlation and coefficients between these anthropometric measurements were calculated. The regression equation of stature as dependable variable were fitted with hand and foot lengths as independent variables. And effectiveness of these regression equations was tested.

Correlation coefficients ( r ) were calculated by using the following formula

$$r = \frac{(X - \bar{X})(Y - \bar{Y})}{n \cdot SD_x \cdot SD_y}$$

Where, X and Y are variables,

$\bar{X}$  is mean of X variable,

$\bar{Y}$  is mean of Y variable,

n = sample size,

$SD_x$  = standard deviation of X and

$SD_y$  = standard deviation of Y

Regression equations were derived by using the following equation,

$$y = a + bx$$

Where,

$$a = \bar{y} - b \bar{x} \quad \text{and}$$

$$b = \frac{xy - n\bar{x}\bar{y}}{x^2 - n\bar{x}^2}$$

x is dependent variable and y is independent variable

$\bar{x}$  is mean of variable x and

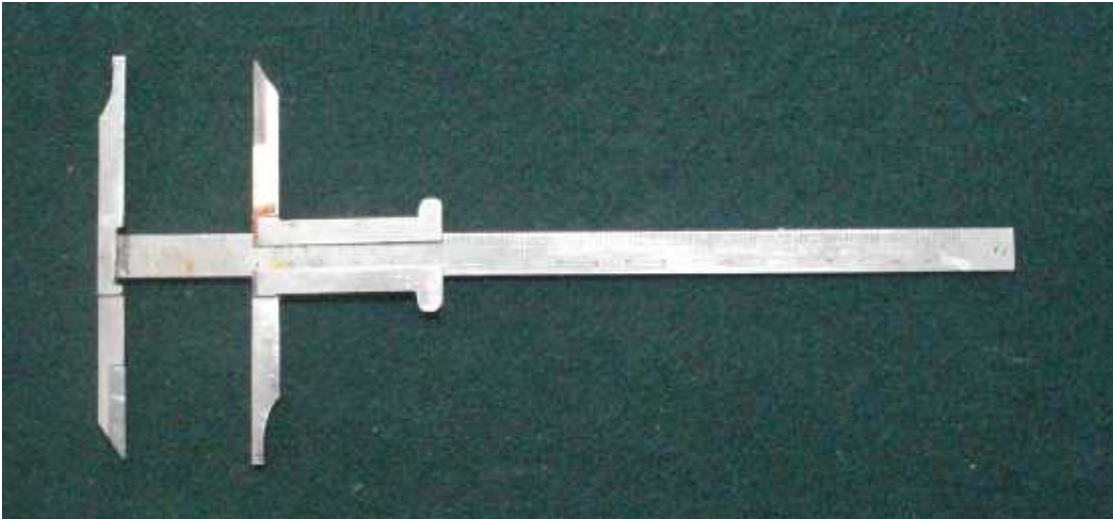
$\bar{y}$  is mean of variable y.

### MATERIALS USED FOR STUDY

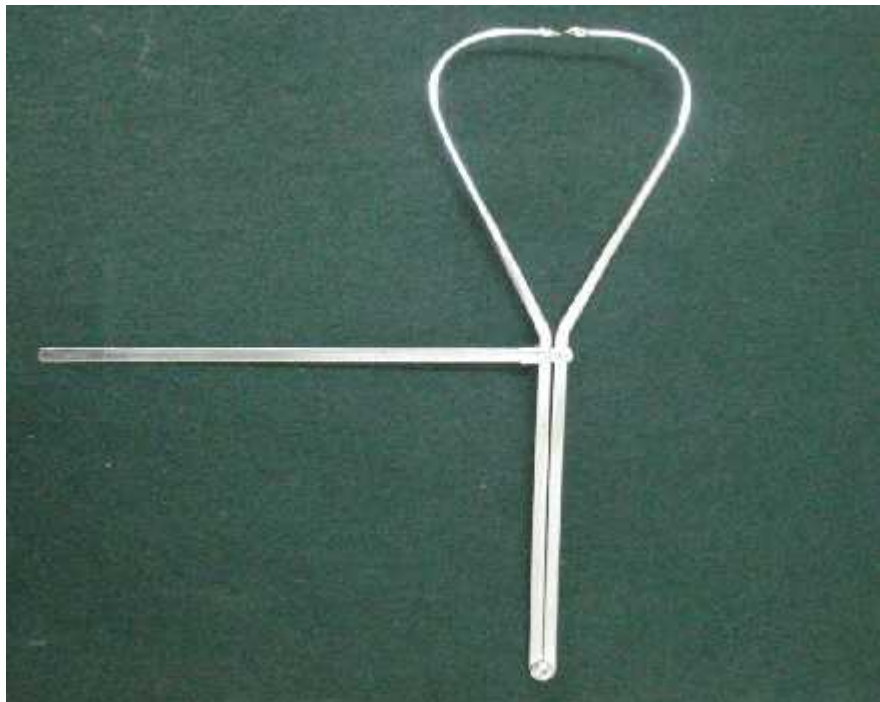
**Figure 2: STADIOMETER**



**Figure 3: SLIDING CALIPERS**



**Figure 4: SPREADING CALIPERS**



**Figure 5: Measurement of Stature (Height). 5(a): Front view, 5(b): Left lateral view and 5(c): Right lateral view.**



**5(a)**



**5(b)**



**5(c)**

**Figure 6: MEASUREMENT OF FOOT LENGTH**



**Figure 7: MEASUREMENT OF HAND LENGTH**



**RESULTS****Study design:**

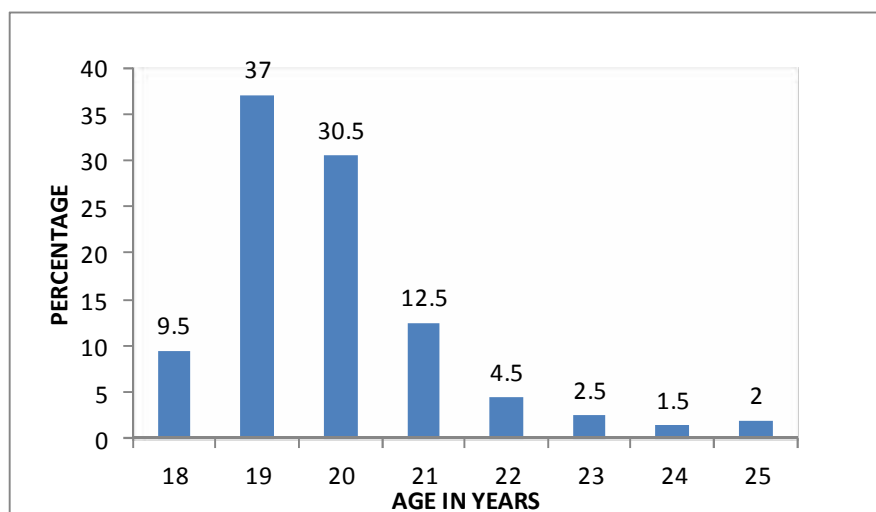
A cross sectional study was conducted on 200 adult subjects (100 males and 100 females) of Belgaum region. The subjects of both the sexes aged between 18-25 years were included in this study. The stature, hand length and foot length of the subjects were measured. An attempt was made to correlate hand length and foot length measurements with the stature and also to derive regression equations for the calculation of stature from hand length and foot length.

The age distribution of the total sample is shown in table 1 and graph 1.

**Table 1: Age distribution of the total sample.**

Age in years	Number	Percentage (%)
18	19	9.5
19	74	37
20	61	30.5
21	25	12.5
22	9	4.5
23	5	2.5
24	3	1.5
25	4	2

**Graph 1: Bar chart showing age distribution of the total sample.**



**Table 2: Mean, Median, Standard Deviation (SD) and Range of age distribution among the study population (total sample).**

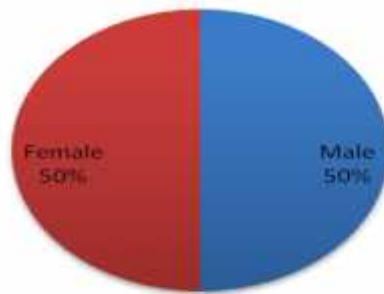
	Males	Females
Number	100	100
Mean	19.94	19.88
Median	20.00	20.00
Standard Deviation(SD)	1.427	1.365
Range	7	7
Minimum Age	18	18
Maximum age	25	25

The age of the study group ranged between 18 and 25 years for both males and females. The mean age of males was 19.94 years and that of females was 19.88 years.

**Table 3: Gender distribution**

Gender	Number	Percentage (%)
Male	100	50
Female	100	50
Total	200	100

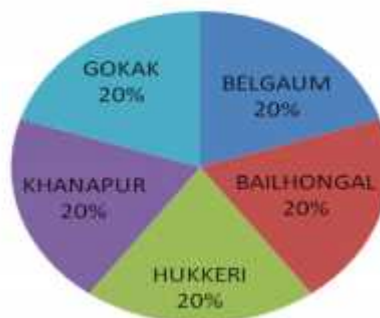
**Graph 2: Pie chart showing gender distribution**



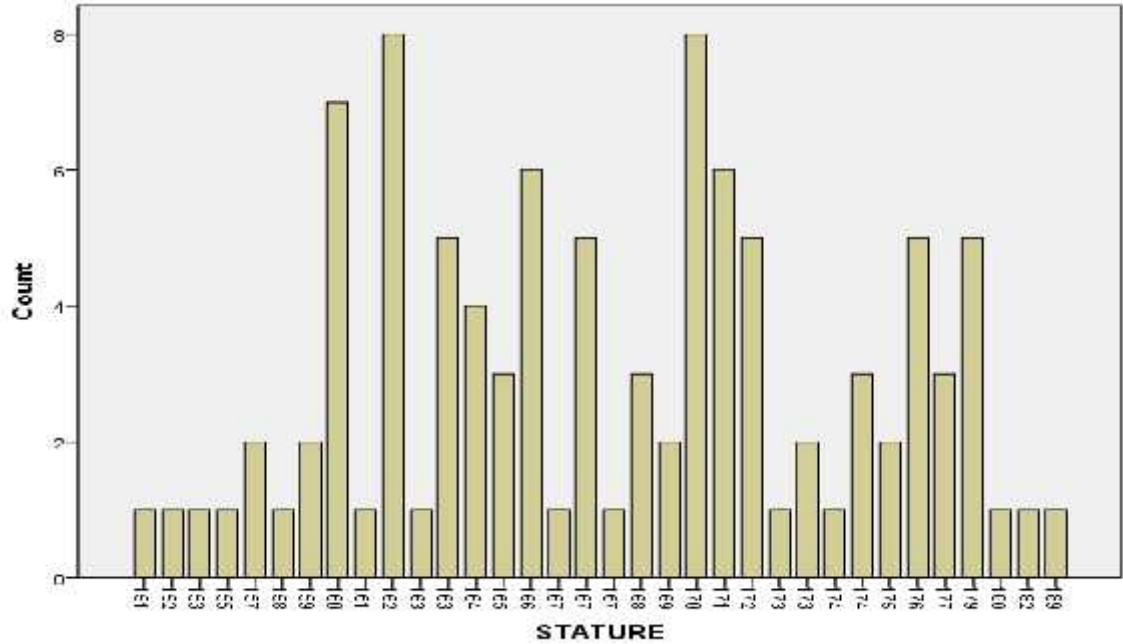
**Gender distribution**

**Graph 3: Pie chart showing percentage-wise distribution of total sample in different places of Belgaum region.**

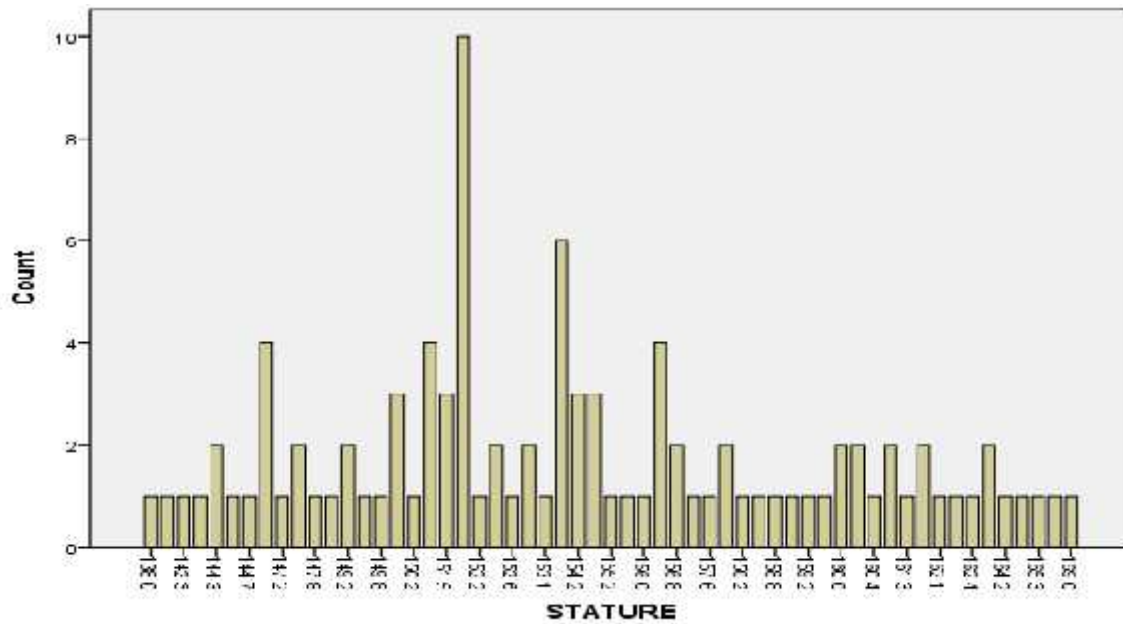
**DISTRIBUTION OF STUDY POPULATION**



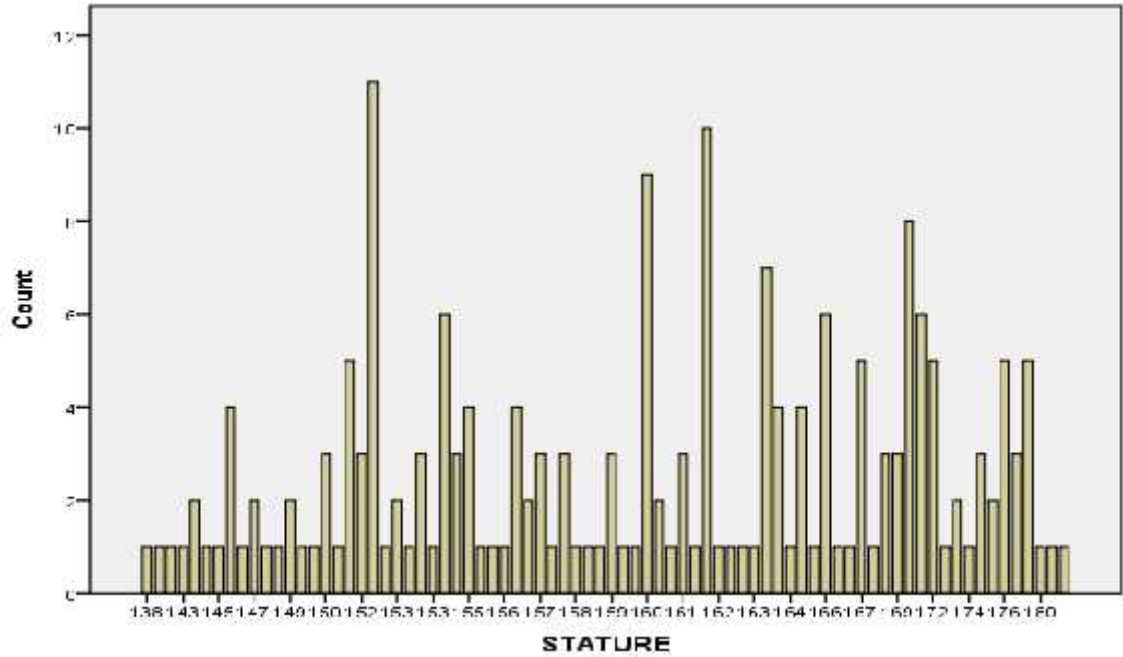
**Graph 4: Bar chart showing stature distribution in male subjects (Stature was measured in centimeters).**



**Graph 5: Bar chart showing stature distribution in female subjects (Stature was measured in centimeters).**



**Graph 6: Bar chart showing stature distribution in total sample (Stature was measured in centimeters).**



**Table 4: Descriptive statistics of parameters studied in male subjects (All parameters were measured in centimeters).**

	LHL	RHL	LFL	RFL	STATURE
NUMBER	100	100	100	100	100
MEAN	18.36	18.53	25.72	25.96	167.81
MEDIAN	18.20	18.50	25.70	25.90	167.15
SD	0.950	0.946	1.364	1.404	7.053
RANGE	5.0	4.7	8.1	8.2	38.0
MINIMUM	16.0	16.1	21.5	21.8	151.0
MAXIMUM	21.0	20.8	29.6	30.0	189.0

Table 4 shows descriptive statistics of various parameters studied in male subjects. The average stature of male subjects was  $167.81 \pm 7.05$  cms and ranged between 151 cms to 189 cms. The average hand length of left side and right side in male subjects were  $18.36 \pm 0.95$  cms and  $18.53 \pm 0.94$  cms respectively. Similarly in male subjects the average foot length of left side and right side were  $25.72 \pm 1.36$  cms and  $25.96 \pm 1.40$  cms respectively.

**Table 5: Descriptive statistics of parameters studied in female subjects (All parameters were measured in centimeters).**

	LHL	RHL	LFL	RFL	STATURE
NUMBER	100	100	100	100	100
MEAN	16.64	16.77	23.49	23.62	153.97
MEDIAN	16.65	16.80	23.40	23.60	154.00
SD	0.824	0.806	0.934	0.920	6.052
RANGE	4.3	4.0	4.7	5.0	31.0
MINIMUM	14.4	14.6	21.2	21.0	138.0
MAXIMUM	18.7	18.6	25.9	26.0	169.0

Table 5 shows descriptive statistics of various parameters studied in female subjects. The average stature of female subjects was  $153.97 \pm 6.5$  cms and ranged between 138 cms to 169 cms. The average hand length of left side and right side in female subjects were  $16.64 \pm 0.82$  cms and  $16.77 \pm 0.80$  cms respectively. Similarly in female subjects the average foot length of left side and right side were  $24.49 \pm 0.93$  cms and  $23.62 \pm 0.92$  cms respectively.

**Table 6: Descriptive statistics of parameters studied in total sample including males and females together (All parameters were measured in centimeters).**

	LHL	RHL	LFL	RFL	STATURE
NUMBER	200	200	200	200	200
MEAN	17.50	17.65	24.60	24.79	160.89
MEDIAN	17.40	17.60	24.45	24.60	160.35
SD	1.237	1.245	1.616	1.664	9.542
RANGE	6.0	6.2	8.4	8.8	51.0
MINIMUM	14.0	14.6	21.2	21.2	138.0
MAXIMUM	21.0	20.8	29.6	30.0	189.0

Table 6 shows descriptive statistics of various parameters studied in total sample (both genders together). The average stature of total sample population was  $160.89 \pm 9.54$  cms and ranged between 138 cms to 189 cms. The average hand length of left side and right side in total sample population were  $17.50 \pm 1.23$  cms and  $17.65 \pm 1.24$  cms respectively. Similarly in total sample population the average foot length of left side and right side were  $24.60 \pm 1.61$  cms and  $24.79 \pm 1.66$  cms respectively.

To assess the statistical differences between the observations of right and left sides, in male subjects and female subjects, paired sample 't' test was performed.

**Table 7: Paired samples ‘t’ test showing statistical difference between right side and left side of males and females.**

Paired samples		t	df	‘P’ value
Pair 1	Male LHL – Male RHL	11.649	99	< 0.001 <sup>**</sup>
Pair 2	Male LFL – Male RFL	9.955	99	< 0.001 <sup>**</sup>
Pair 3	Female LHL – Female RHL	9.510	99	< 0.001 <sup>**</sup>
Pair 4	Female LFL – Female RFL	8.606	99	< 0.001 <sup>**</sup>

<sup>\*\*</sup>Statistically highly significant.

Statistical analysis shown in the table 7 indicated that bilateral variations were statistically significant (P<0.001) for all the measurements in both males and females.

**Table 8: Paired samples ‘t’ test showing statistical difference between males and females.**

Paired samples		t	df	‘P’ value
Pair 1	Male LHL – Female LHL	13.354	99	< 0.001 <sup>**</sup>
Pair 2	Male RHL – Female RHL	13.694	99	< 0.001 <sup>**</sup>
Pair 3	Male LFL – Female LFL	12.520	99	< 0.001 <sup>**</sup>
Pair 4	Male RFL – Female RFL	13.042	99	< 0.001 <sup>**</sup>

<sup>\*\*</sup>Statistically highly significant.

Statistical differences between male and female observations were assessed by performing paired sample ‘t’ test. Statistical analysis shown in the table 8 indicated that the statistical difference between male and female observations were significant (P<0.001).

**Table 9: Correlaltion coefficient (r) between dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in males.**

Parameters	Pearson correlation coefficient(r)	'P' value
Male LHL	0.740	< 0.001**
Male RHL	0.753	< 0.001**
Male LFL	0.700	< 0.001**
Male RFL	0.705	< 0.001**

\*\*Correlation is significant.

All the parameters in male sample exhibited statistically significant ( $P < 0.01$ ) positive correlations with the stature. It was also observed that in males, stature had the highest correlation with right hand length ( $r = 0.753$ ) and lowest correlation with left foot length ( $r = 0.700$ ).

**Table 10: Correlaltion coefficient (r) between dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in females.**

Parameters	Pearson correlation coefficient(r)	'P' value
Female LHL	0.633	< 0.001**
Female RHL	0.661	< 0.001**
Female LFL	0.540	< 0.001**
Female RFL	0.529	< 0.001**

\*\*Correlation is significant.

All the parameters in female sample exhibited statistically significant ( $P < 0.001$ ) positive correlations with the stature. It was also observed that in females, stature had the

highest correlation with right hand length ( $r = 0.661$ ) and lowest correlation with right foot length ( $r = 0.700$ ).

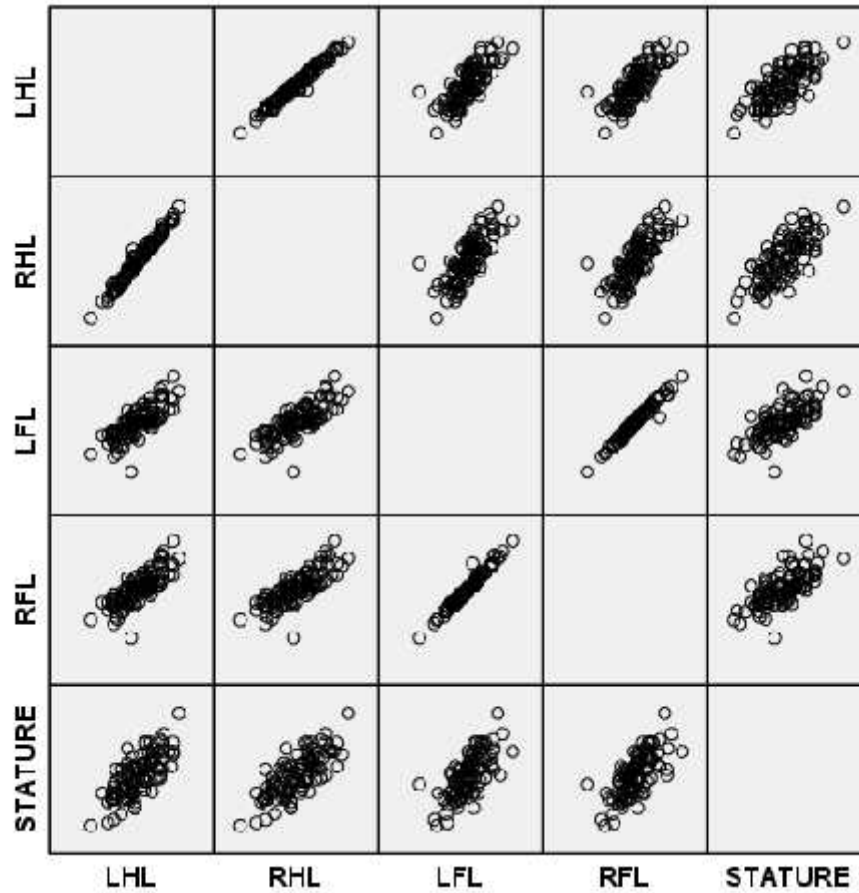
**Table 11: Correlation coefficient (r) between dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in the total sample (both genders together).**

Parameters	Pearson correlation coefficient(r)	'P' value
LHL	0.850	< 0.001 <sup>**</sup>
RHL	0.863	< 0.001 <sup>**</sup>
LFL	0.820	< 0.001 <sup>**</sup>
RFL	0.823	< 0.001 <sup>**</sup>

<sup>\*\*</sup>Correlation is significant.

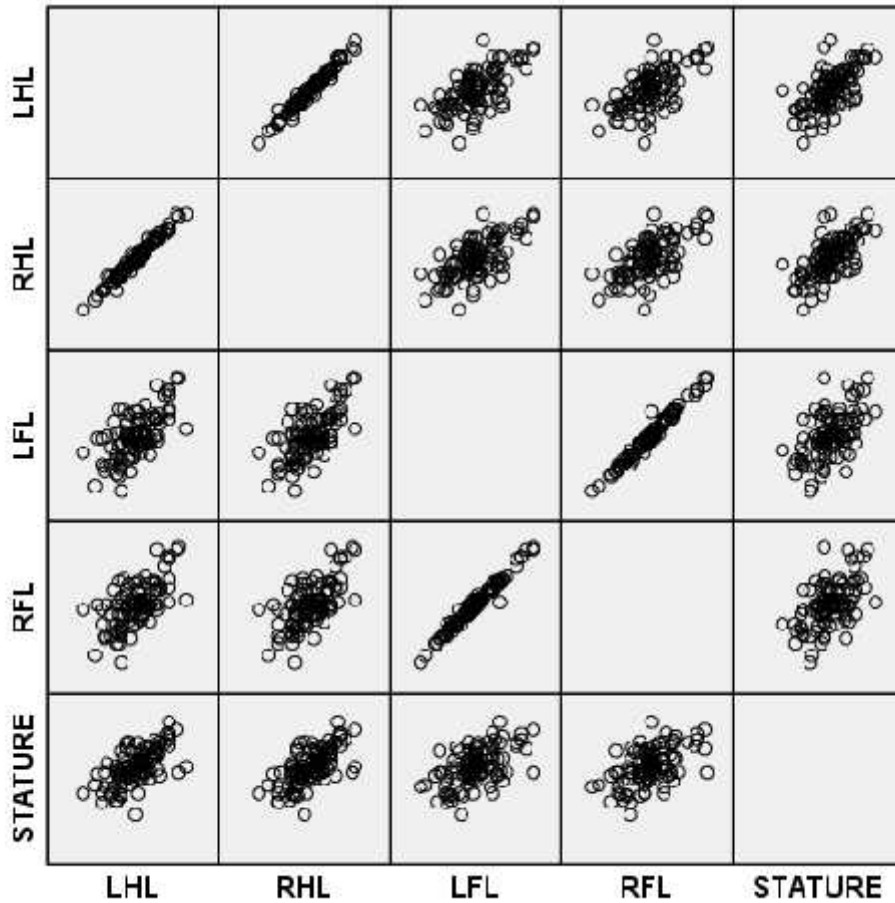
All the parameters in the total sample (both genders together) exhibited statistically significant ( $P < 0.001$ ) positive correlations with the stature. It was also observed that in females, stature had the highest correlation with right hand length ( $r = 0.863$ ) and lowest correlation with left foot length ( $r = 0.820$ ).

**Graph 7: Scatterplot matrix representing relationship between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in males.**



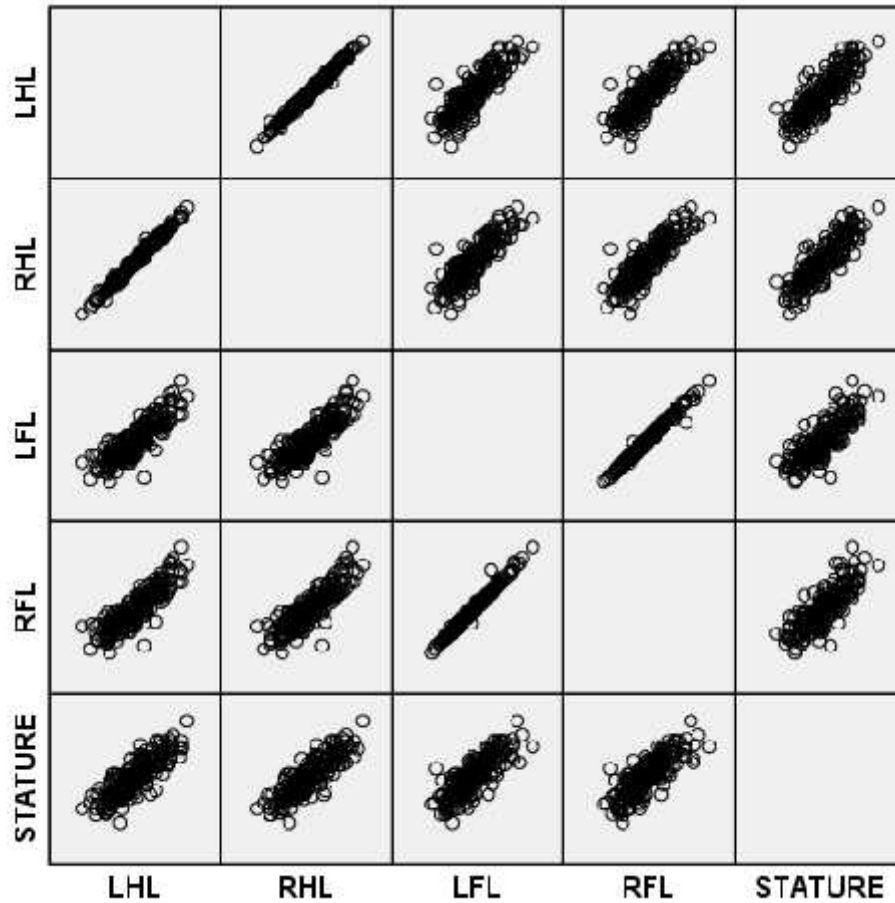
All the relations between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in males had strong association as they were in a straight line in the scatter plot matrix.

**Graph 8: Scatterplot matrix representing relationship between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in females.**



All the relations between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in females had strong association as they were in a straight line in the scatter plot matrix.

**Graph 9: Scatterplot matrix representing relationship between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in total sample.**



All the relations between the dependant variable (stature) and explanatory variables (LHL, RHL, LFL and RFL) in the total sample (both genders together) had strong association as they were in a straight line in scatter plot matrix.

The estimation of the regression coefficients obtained using the method of least-squares of all possible (simple and multiple) linear regression equations and their standard errors (SE) for each of the three groups is given in table 12.

**Table 12: Regression coefficients and their SE of all possible (simple and multiple) linear regression equations for male, female and total sample (both genders together - BGT).**

Sex	DV	EV	a	b <sub>1</sub>	SE	b <sub>2</sub>	SE
Male	S	LHL	66.998	5.492	0.504		
	S	RHL	63.700	5.617	0.496		
	S	LFL	74.672	3.622	0.373		
	S	RFL	75.836	3.543	0.360		
	S	LHL&LFL	58.536	3.669	0.773	1.630	0.539
	S	RHL&RFL	57.565	3.866	0.785	1.472	0.528
Female	S	LHL	76.037	4.685	0.582		
	S	RHL	69.973	5.010	0.577		
	S	LFL	71.461	3.515	0.556		
	S	RFL	71.346	3.498	0.569		
	S	LHL&LFL	59.564	3.607	0.747	1.465	0.657
	S	RHL&RFL	55.964	4.105	0.733	1.235	0.639
BGT	S	LHL	46.189	6.556	0.289		
	S	RHL	44.267	6.607	0.275		
	S	LFL	41.748	4.843	0.240		
	S	RFL	43.916	4.718	0.231		
	S	LHL&LFL	36.097	4.268	0.534	2.037	0.408
	S	RHL&RFL	36.602	4.585	0.525	1.747	0.393

In the table 12 Dependant Variable(DV) is stature and Explanatory Variables (EV) are LHL, RHL, LFL and RFL. In this table ‘a’ is constant, whereas b<sub>1</sub> and b<sub>2</sub> are regression coefficients of independent variables.

Regression equations can be calculated by using the following formulae.

For simple linear regression,

$$\text{Stature} = a + b_1x ,$$

And, for multiple linear regression,

$$\text{Stature} = a + b_1x_1 + b_2x_2$$

Where,

a = constant,

$b_1$  and  $b_2$  are regression coefficients of independent variables,

x,  $x_1$  and  $x_2$  are explanatory variables.

Using above equations regression analysis of observations was performed separately for each sex and also for each parameter studied.

**Table 13: Linear regression equations for various parameters studied in males.**

a) Stature = 66.998 + 5.492(LHL)
b) Stature = 63.700 + 5.617(RHL)
c) Stature = 74.672 + 3.622(LFL)
d) Stature = 75.863 + 3.543(RFL)

**Table 14: Multiple regression equations for various parameteres studied in males.**

a) Stature = 60.260 + 2.417(RHL+RFL)
b) Stature = 58.536 + 3.669(LHL) + 1.630(LFL)

**Table 15: Linear regression equations for various parameters studied in females.**

a) Stature = 76.037 + 4.685(LHL)
b) Stature = 69.973 + 5.010(RHL)
c) Stature = 71.461 + 3.515(LFL)
d) Stature = 71.346 + 3.498(RFL)

**Table 16: Multiple regression equations for various parameteres studied in females.**

a) Stature = 59.576 + 3.607(LHL) + 1.465(LFL)
b) Stature = 55.964 + 4.105(RHL) + 1.235(RFL)

**Table 17: Linear regression equations for various parameters studied in total sample ( both genders together).**

a) Stature = 46.189 + 6.556(LHL)
b) Stature = 44.267 + 6.607(RHL)
c) Stature = 41.748 + 4.843(LFL)
d) Stature = 43.916 + 4.718(RFL)

**Table 18: Multiple regression equations for various parameteres total sample ( both genders together).**

a) Stature = 36.097 + 4.268(LHL) + 2.037(LFL)
---

b) Stature = 36.602 + 4.585(RHL) + 1.747(RFL)
---

The computed values of the multiple correlation coefficients R, R<sup>2</sup>, Adjusted R<sup>2</sup> and SEE (Standard Error of Estimate) of all possible simple and multiple linear regression equations for males, females and total sample (both genders together) are given in table 19.

**Table 19: R, R<sup>2</sup>, Adjusted R<sup>2</sup> and SEE values of all possible (simple and multiple) linear regression equations with respect to males, females and total sample (both genders together - BGT).**

Sex	DV	EV(s)	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SEE
Male	S	LHL	0.740	0.547	0.543	4.769
	S	RHL	0.753	0.567	0.563	4.644
	S	LFL	0.700	0.490	0.485	5.060
	S	RFL	0.705	0.498	0.493	5.024
	S	LHL&LFL	0.766	0.586	0.578	4.582
	S	RHL&RFL	0.774	0.599	0.591	4.511
	Female	S	LHL	0.633	0.401	0.395
S		RHL	0.661	0.437	0.431	4.559
S		LFL	0.540	0.292	0.285	5.112
S		RFL	0.529	0.280	0.273	5.155
S		LHL&LFL	0.656	0.430	0.418	4.610
S		RHL&RFL	0.677	0.458	0.447	4.495
BGT		S	LHL	0.850	0.722	0.721
	S	RHL	0.863	0.744	0.743	4.837
	S	LFL	0.820	0.673	0.671	5.470
	S	RFL	0.823	0.678	0.676	5.430
	S	LHL&LFL	0.868	0.753	0.751	4.765
	S	RHL&RFL	0.876	0.768	0.765	4.622

The best simple linear regression model for males with high values for the coefficients of determination R<sup>2</sup> as 0.567, adjusted R<sup>2</sup> as 0.563 and with the low SEE value of 4.644 was as follows,

$$\text{Stature} = 63.700 + 5.617(\text{RHL})$$

The best simple linear regression model for females with high values for the coefficients of determination R<sup>2</sup> as 0.437, adjusted R<sup>2</sup> as 0.431 and with the low SEE value of 4.599 was as follows,

$$\text{Stature} = 69.973 + 5.010(\text{RHL})$$

The best simple linear regression model for total sample (both genders together) with high values for the coefficients of determination  $R^2$  as 0.744, adjusted  $R^2$  as 0.743 and with the low SEE value of 4.837 was as follows,

$$\text{Stature} = 44.267 + 6.607(\text{RHL})$$

For overall study the best simple linear regression model with high values for the coefficients of determination  $R^2$  as 0.768, adjusted  $R^2$  as 0.765 and with the low SEE value of 4.622 was as follows,

$$\text{Stature} = 36.602 + 4.585(\text{RHL}) + 1.747(\text{RFL})$$

It was observed that multiple regression models were with highest values of  $R$ ,  $R^2$ , adjusted  $R^2$  and with lowest values of SEE. Therefore the interpretation of these results suggested that multiple regression equations were the best indicators of stature estimation compared to linear regression equations.

### DISCUSSION

The determination of stature is an important step in the identification of dismembered remains<sup>2</sup>. Population variations in anthropometric dimensions do exist and are attributed to genetic and environmental factors<sup>1</sup>. Although stature is partly determined by length of bones in upper limb and lower limb, it is also influenced by many other factors such as genetics, environment, gender, age and physical activity. In addition, the rate of growth in males and females varies during the course of development, with ossification being complete and skeletal maturity attained by the age of 25 years<sup>52</sup>.

The result of present study shows that the dimensions of hand lengths and foot lengths can be successfully used for estimation of stature in Belgaum region by law enforcement agencies and forensic experts. The only precaution to be taken into consideration is that these formulae are applicable to the Belgaum region population from which the data has been collected. It is due to the inherent population variation in these dimensions, which may be attributed to genetic, life style differences and environmental factors like nutrition, climate etc.

The present study is unique in its sample collection. Belgaum region is geographically unique in its environment, culture and food habits. No studies have been done for the estimation of stature from hand lengths and foot lengths in the Belgaum region. Hence the study intends to fill this lacuna.

In the present study males showed higher mean values in all parameters studied when compared with mean values of female parameters. Studies done to estimate stature by Abdel malek<sup>1</sup> and OP Jasuja<sup>36</sup> have reported statistically significant higher values for

males. These statistically significances between males and females are due to the fact that fusion of epiphysis of bones occurs earlier in males than females. Males have about two more years of bone growth than females<sup>1</sup>.

The table 20 shows variation in mean stature between same sex group of different study groups. The stature is determined by several factors which include genetic and environmental factors. This is the reason for wide variation in mean stature among the individuals of same sex belonging to different endogamous groups.

**Table 20: The comparison of mean stature in males and females of different study groups.**

Sl. No.	Author	Year	Study population	Mean ± SD of Stature (in cms)	
				Males	Females
1	Qamra et al <sup>27</sup>	1980	Northwest India	168 ± 0.26	155.7 ± 0.25
2	Bhatnagar DP <sup>29</sup>	1984	Punjabi males	167.52 ± 3.80	-----
3	Abdel Malek et al <sup>1</sup>	1990	Egypt students	172.8 ± 7.2	158.9 ± 5.37
4	Giles et al <sup>19</sup>	1991	Americans	174.52 ± 6.61	162.95 ± 6.52
5	Jasuja OP <sup>48</sup>	2004	Jat Sikhs	175.2 ± 5.24	159.7 ± 5.17
6	Sanli SG <sup>52</sup>	2005	Turks	175.05 ± 6.12	159.9 ± 4.92
7	Sen J <sup>63</sup>	2008	Rajbanshis	162.23 ± 5.69	149.53 ± 5.37
8	Kanchan et al <sup>70</sup>	2010	North Indian	166.39 ± 5.6	159.56 ± 5.1
9	Present study	2012	Belgaum region	167.81 ± 7.05	153.97 ± 6.05

The present study showed bilateral symmetry for all the parameters studied in males and females. Studies conducted by OP Jasuja<sup>38</sup> reported significant asymmetry for foot length and Kewal krishan<sup>58</sup> reported significant asymmetry for hand length.

In the present study all the parameters showed positive correlation with the stature and thus the results can be applied for stature estimation. In both males and females hand length has higher correlation with stature. Therefore hand length is the best parameter for the estimation of stature in males and females. The relatively low SEE (standard error of estimate) for hand length in males (4.644) and in females (4.559) ensures better accuracy in stature estimation.

The presence of positive correlations between stature and other study parameters facilitates formulation of regression equations which can be successfully utilized for stature estimation in the Belgaum region population.

Comparison of various studies conducted to estimate stature from hand length measurements are given in table 21. Positive correlations were found between the hand length and stature in all other studies and they were in the ranges of 0.47 to 0.73 and 0.33 to 0.70 in males and females respectively. This shows that hand length is a useful parameter in stature estimation. The higher values of correlation coefficients of males and females for estimation of stature from hand length in the present study were 0.753 and 0.661 respectively. Male hand length parameter showed statistically significant and highly positive correlation with stature than female hand length parameter. The reason for gender difference in the present study is a topic of further investigation and analysis.

**Table 21: Comparison of various studies done to estimate stature from hand length (HL)**

Sl. No.	Author	Year	Population	Sex	Correlation coefficient (r)	Regression Equation	SEE
1	Abdel Malek <sup>1</sup>	1990	Egyptian	Male	0.64	$S = 68.38 + 5.25(HL)$	----
2	Abdel Malek <sup>1</sup>	1990	Egyptian	Female	0.69	$S = 71.07 + 4.81(HL)$	----
3	Jasuja OP <sup>48</sup>	2004	Jat Sikhs	Male	---	$S = 169.51 + 5.22(HL)$	4.00
4	Jasuja OP <sup>48</sup>	2004	Jat Sikhs	Female	---	$S = 133.96 + 1.40(HL)$	5.12
5	Sanli SG <sup>52</sup>	2005	Turks	Male	0.72	$S = 43.95 + 3.29(HL)$	42.66
6	Sanli SG <sup>52</sup>	2005	Turks	Female	0.71	$S = 74.31 + 2.38(HL)$	30.91
7	Kewal Krishan <sup>58</sup>	2007	Rajputs	Male	0.30	$S = 88.24 + 4.39(HL)$	5.17
8	Kewal Krishan <sup>58</sup>	2007	Rajputs	Female	0.33	$S = 81.31 + 4.42(HL)$	3.78
9	Prateek Rastogi <sup>17</sup>	2008	South Indian students	Male	0.73	$S = 69.01 + 5.46(HL)$	4.85
10	Prateek Rastogi <sup>17</sup>	2008	South Indian students	Female	0.68	$S = 83.04 + 4.45(HL)$	3.76
11	Present study	2012	Belgaum region	Male	0.75	$S = 63.70 + 5.61(HL)$	4.64
12	Present study	2012	Belgaum region	Female	0.66	$S = 69.97 + 5.01(HL)$	4.56

The findings in the present study are comparable with other Indian studies conducted on hand length to estimate stature.

Comparison of various studies to estimate stature from foot length measurements are given in table 22. The values of higher correlation coefficients of males and females for estimation of stature from foot length in the present study were 0.705 and 0.540 respectively. The difference in the correlation coefficients in males and females may be attributed to environmental, social and genetic factors.

Male foot length showed statistically significant highly positive correlation with the stature than female foot length. Positive correlations were found between foot length and stature in all the other studies and they were in the ranges of 0.56 to 0.80 and 0.50 to 0.80 in males and females respectively. This shows that foot length is a useful parameter in stature estimation.

**Table 22: Comparison of various studies done to estimate stature from foot length (FL)**

Sl. No	Author	Year	Population	Sex	Correlation coefficient (r)	Regression Equation	SEE
1	Philip TA <sup>35</sup>	1988	Karnataka Students	Male	0.71	$S = 72.40 + 3.80(FL)$	4.92
2	Philip TA <sup>35</sup>	1988	Karnataka Students	Female	0.83	$S = 38.57 + 5.04(FL)$	4.37
3	Giles E <sup>19</sup>	1991	US Army	Male	0.68	$S = 82.21 + 3.45(FL)$	4.86
4	Giles E <sup>19</sup>	1991	US Army	Female	0.69	$S = 75.07 + 3.61(FL)$	4.70
5	Sanli G <sup>52</sup>	2005	Turkey	Male	0.72	$S = 37.23 + 2.58(FL)$	43.04
6	Sanli G <sup>52</sup>	2005	Turkey	Female	0.69	$S = 74.31 + 1.73(FL)$	35.45
7	Kewal Krishan <sup>58</sup>	2007	Rajputs	Male	0.73	$S = 68.09 + 4.05(FL)$	4.44
8	Kewal Krishan <sup>58</sup>	2007	Rajputs	Female	0.74	$S = 71.94 + 3.70(FL)$	3.50
9	Ilayperuma I <sup>66</sup>	2008	Galle, Sri Lanka	Male	0.73	$S = 79.04 + 3.59(FL)$	5.22
10	Ilayperuma I <sup>66</sup>	2008	Galle, Sri Lanka	Female	0.72	$S = 65.54 + 3.94(FL)$	5.75
11	Present study	2012	Belgaum region	Male	0.70	$S = 75.86 + 3.54(FL)$	5.02
12	Present study	2012	Belgaum region	Female	0.54	$S = 71.46 + 3.51(FL)$	5.11

The anthropometric data of the present study can be used to obtain certain population specific anthropometric indices among the Belgaum region population. It can be used to perform discriminant analysis for sex determination. The data and results obtained in the present study, to the best of knowledge of the author, is the first ever documented anthropological work done on the population of Belgaum region.

### CONCLUSION

With respect to age, sex and racial groups, dimensions and body proportions are widely variable. All the parts of the body show biological variation. This fact can be utilized to estimate the size of one part of the body using other part of the body. The same principle holds good to estimate stature from body parts.

The mean values of stature, hand length and foot length were found to be greater for males than females in Belgaum region population with statistically significant intersex difference.

Right hand length measurement showed highest positive correlation with stature in males, females and total sample (both genders together). As the hand length measurement have higher statistically significant positive correlation with stature than that of foot length measurements with stature, the hand length can be considered as a better predictor of stature than foot length in the Belgaum region population. But this does not rule out the importance of foot length in stature estimation as there may be situation when only a part of foot may be available for analysis, where only foot length can be measured.

Simple and multiple linear regression equations have been derived from the collected data which are useful to estimate stature from hand length and foot length in the Belgaum region population.

These types of studies are of medicolegal importance, as the first step in forensic analysis in establishing the identity of the person in question, where stature is one of the primary characteristics of identification. These studies are also of anthropological

importance as it helps to know the differences between different population groups. If the same study is conducted on the same population group after several years, it will help to identify the micro-evolutionary changes.

Thus it can be concluded that both hand length and foot length can be used to estimate stature in Belgaum region population. But the highest correlation coefficient between hand length and stature in males, females and total sample (both genders together), with lowest standard error of estimate, indicates that hand length provides highest reliability and accuracy in estimating stature in Belgaum region population.

**SUMMARY**

The study was taken up with the aim of finding out whether there is any correlation of stature with hand length and foot length, and also to find out which parameter is best among them to estimate the stature in Belgaum region population. The study was also aimed at to derive regression equations to calculate stature in Belgaum population.

A cross sectional study was carried out on 100 males and 100 females belonging to the Belgaum region. The individuals of both the sexes aged between 18 years to 25 years were included in the study. The stature (height), hand length and foot length of both the sides of the individuals were measured. The stature was measured as vertical distance from vertex to the floor in mid-sagittal plane with the help of stadiometer. The hand length and foot length were measured with the help of sliding calipers and spreading calipers respectively.

Statistical analysis indicated that the bilateral variation was significant ( $P < 0.001$ ) for all the measurement in both males and females. The statistical analysis using paired sample 't' test showed that the statistical difference between males and females was highly significant for all the parameters measured ( $P < 0.001$ ).

The statistical analysis showed that the correlation between stature and various parameters studied in males and females were found to be positive and statistically highly significant. The highest correlation coefficient was obtained between right hand length and stature (0.753), and lowest for left foot length and stature (0.700) among males. Similarly the highest correlation coefficient was obtained between right hand length

stature (0.661) and lowest for right foot length (0.529) among females. The significant positive correlations between the explanatory variables and stature indicate that these variables can be successfully used to predict stature.

Linear and multiple regression equations for stature estimation were calculated separately for males and females. Similarly linear and multiple regression equations for stature estimation were calculated for total sample (both genders together). Multiple regression equations provide slightly better measure of stature as compared to the linear regression equations.

The present study can be successfully used for estimation of stature from hand length and foot length in Belgaum region by law enforcement agencies and forensic experts.

The present study is the first ever documented anthropological work on the population of Belgaum region.

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**PROFORMA**

**“A STUDY ON STATURE ESTIMATION FROM HAND AND  
FOOT LENGTHS IN ADULT SUBJECTS OF BELGAUM  
REGION”**

**Sl. No:****Name:****Age:****Sex:****Religion:****Address:****Weight:****Dietary Habits: Veg/Non-Veg****Right handed /Left handed person :**

<b>PARAMETERS (Measured in cms)</b>	<b>READING I</b>	<b>READING II</b>	<b>READING III</b>	<b>MEAN</b>
<b>LEFT HAND LENGTH</b>				
<b>RIGHT HAND LENGTH</b>				
<b>LEFT FOOT LENGTH</b>				
<b>RIGHT FOOT LENGTH</b>				
<b>STATURE(HEIGHT)</b>				

**VOLUNTEER'S CONSENT FORM**

**Principal Investigator**  
( Name & Address )

**Dr.** -----  
Department of Anatomy,  
J.N. Medical College, Belgaum.

**Co- Investigator**  
( Name & Address )

**Dr.** -----  
Department of Anatomy,  
J.N.Medical College, Belgaum.

**Purpose of the study and brief description of procedure to be carried out.**

The purpose of this study is to estimate stature from hand length and foot length. Stature is the distance between vertex and floor, in the anatomical position and the head in Frankfort plane. Stature is measured with the help of Anthropometer(Stadiometer). Hand length is the linear distance between the distal wrist crease and distal end of middle finger. Foot length is the maximum distance between most posteriorly projecting point on the heel and most anteriorly projecting toe. Foot length is measured with the help of Spreading calipers and Hand length is measured with Sliding calipers.

**Risks and Benefits**

There are no risks and benefits to the subjects involved in this study.

**Privacy and confidentiality**

Privacy and confidentiality of the details of the study subjects will be maintained. The identity of the study subjects will not be disclosed.

**This study has been explained to me and I understand:**

- a. What the study involves.
- b. That refusal to participate will not affect me in any way.
- c. That I may not get any benefit from the study.
- d. That I may withdraw at any time.

**I therefore agree to take part in this study**

Signature of the subject.....  
Full Name: .....  
Date: .....  
Full Address: .....

**I have been present while the procedure has been explained to the subject and I have witnessed his / her consent to take part.**

Signature of the witness.....  
Full Name: .....  
Date: .....  
Full Address: .....

## MASTER CHART

**Table showing hand length, foot length and stature (height) of both left and right sides of the body in male subjects included in the study.**

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
1	21	M	BELGAUM	18	18.2	26.2	26.5	162
2	21	M	BELGAUM	18.2	18.3	24.6	24.8	159
3	19	M	BELGAUM	17.2	17.3	23.6	23.6	160
4	21	M	BELGAUM	18.7	18.7	26.8	27	170
5	21	M	BELGAUM	18.2	18.3	26.2	26.2	157
6	21	M	BELGAUM	17.1	17.3	24	24.5	158
7	20	M	BELGAUM	17	17.1	25	25.1	160
8	24	M	BELGAUM	17.8	18	25.8	26.1	172
9	20	M	BELGAUM	16.5	16.8	24.6	24.8	162
10	22	M	BELGAUM	18.3	18.3	26.8	27	171
11	19	M	BELGAUM	18	18	25	25.1	160
12	19	M	BELGAUM	17.5	17.6	23.8	24	155
13	20	M	BELGAUM	18.2	18.7	26.6	26.8	162
14	19	M	BELGAUM	18.7	18.9	27.2	27.3	179
15	19	M	BELGAUM	18	18.2	25.5	25.6	163
16	19	M	BELGAUM	18.7	18.8	25.6	25.7	163
17	19	M	BELGAUM	18.3	18.7	25.6	25.7	166
18	18	M	BELGAUM	18.5	18.8	26.5	26.7	164
19	20	M	BELGAUM	18.5	18.6	25.7	25.8	170
20	21	M	BELGAUM	19	19.1	27.8	27.8	172
21	20	M	BAILHONGAL	19.5	19.8	28.5	28.7	168
22	21	M	BAILHONGAL	20.2	20.2	29.6	30	176
23	20	M	BAILHONGAL	18.4	18.5	24.2	24.8	169
24	23	M	BAILHONGAL	17.1	17.2	22.8	23	153
25	23	M	BAILHONGAL	17.8	18.1	25.1	25.3	160
26	19	M	BAILHONGAL	19.5	19.6	27.9	28.1	180
27	19	M	BAILHONGAL	17.8	18.1	25.8	26.1	170
28	19	M	BAILHONGAL	16.8	17	24.7	24.8	159
29	21	M	BAILHONGAL	17	17.5	24.7	24.8	162
30	20	M	BAILHONGAL	17.2	17.2	24.8	25	170
31	19	M	BAILHONGAL	16.8	16.8	23.9	24.1	152
32	22	M	BAILHONGAL	17.5	17.8	25.1	25.3	170
33	25	M	BAILHONGAL	18.7	19	26.8	27	166

## ANNEXURE - III

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
34	20	M	BAILHONGAL	15.9	16.1	23	23.3	151
35	22	M	BAILHONGAL	17.1	17.3	25	25.4	164
36	21	M	BAILHONGAL	18	18.2	26.1	26.1	162
37	20	M	BAILHONGAL	20.5	20.8	28.3	28.5	189
38	20	M	BAILHONGAL	18	18.1	25.6	25.7	162
39	19	M	BAILHONGAL	18.2	18.3	25.5	25.5	166
40	21	M	BAILHONGAL	18	18.4	21.5	21.8	165
41	21	M	HUKKERI	17.1	17.5	24.8	25	165
42	20	M	HUKKERI	18.5	18.6	25.8	26	175
43	22	M	HUKKERI	19.7	19.8	28.7	29.1	182
44	20	M	HUKKERI	19.6	20	28	28.8	177
45	22	M	HUKKERI	17.6	17.8	25.7	25.8	164
46	20	M	HUKKERI	19.2	19.5	26.5	27.1	173.5
47	20	M	HUKKERI	18.1	18.2	25.3	25.6	163
48	21	M	HUKKERI	18.1	19	26	26.1	174
49	21	M	HUKKERI	19.7	19.9	27.9	28	176
50	18	M	HUKKERI	19.1	19.2	26	26.1	172.5
51	19	M	HUKKERI	17.8	18.1	26.7	26.8	177
52	20	M	HUKKERI	18.7	18.8	25.8	26	172
53	21	M	HUKKERI	18.7	18.8	26.2	26.3	172
54	20	M	HUKKERI	19.4	19.4	26.5	26.6	170
55	19	M	HUKKERI	19	19	25.3	25.4	167
56	20	M	HUKKERI	18.9	19	25.7	25.8	176
57	18	M	HUKKERI	17.5	17.6	24.6	24.7	165
58	19	M	HUKKERI	17.5	17.5	24.8	25.2	167.3
59	19	M	HUKKERI	19	19	27	27.5	179
60	21	M	HUKKERI	19.1	19.2	26.8	27	177
61	21	M	GOKAK	19.6	19.8	26.3	26.6	179
62	20	M	GOKAK	19.4	19.5	26.1	28.1	171
63	20	M	GOKAK	19	19	27.2	27.3	173
64	20	M	GOKAK	18.1	18.3	24.6	24.7	171
65	21	M	GOKAK	18.1	18.1	25.7	25.8	171
66	20	M	GOKAK	20.2	20.5	27.6	27.9	175
67	20	M	GOKAK	19.3	19.4	25.8	26.1	166.8
68	24	M	GOKAK	17.1	17.2	24.9	25.5	160
69	22	M	GOKAK	19.6	19.6	28	28.7	170
70	21	M	GOKAK	17.2	17.6	24.5	24.5	166
71	19	M	GOKAK	17.7	17.7	25.7	25.7	164
72	25	M	GOKAK	18.6	19	27.2	27.3	167

**ANNEXURE - III**

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
73	19	M	GOKAK	20.2	20.3	26.8	27.1	179
74	19	M	GOKAK	17.9	18.1	24.5	24.8	161
75	19	M	GOKAK	17.8	18.2	25.2	25.2	163
76	18	M	GOKAK	17.1	17.3	24.1	24.3	162
77	19	M	GOKAK	17.8	18	24.3	24.6	168
78	19	M	GOKAK	19	19.3	25.6	26	171
79	25	M	GOKAK	18.1	18.7	25.6	25.6	170
80	18	M	GOKAK	18.6	19	26.3	26.3	167
81	18	M	KHANAPUR	17	17.1	24.3	24.6	160
82	19	M	KHANAPUR	19.5	19.6	26	26.3	167
83	20	M	KHANAPUR	19.4	19.5	26.1	26.3	176
84	20	M	KHANAPUR	18	18.2	24.8	25	168
85	18	M	KHANAPUR	19	19.3	25.8	26.1	172
86	18	M	KHANAPUR	17.8	17.9	25.5	25.7	169
87	19	M	KHANAPUR	18.8	18.9	25.8	26.1	166
88	19	M	KHANAPUR	19.1	19.3	26	26.2	174
89	18	M	KHANAPUR	18.4	18.5	25.8	26.1	167
90	18	M	KHANAPUR	19.6	19.7	27	27.3	174
91	19	M	KHANAPUR	20.1	20.3	27.8	28.1	171
92	19	M	KHANAPUR	17.3	17.5	23.1	23.4	162
93	19	M	KHANAPUR	18.2	18.3	24.8	24.8	157
94	18	M	KHANAPUR	17.5	17.5	24.3	24.8	163
95	19	M	KHANAPUR	20	20.1	26.8	27.1	176
96	20	M	KHANAPUR	18.2	18.4	24.5	24.5	166
97	18	M	KHANAPUR	18.8	19.2	26.5	27.1	179
98	19	M	KHANAPUR	19.1	19.1	26.1	26.3	173
99	19	M	KHANAPUR	17.6	17.7	23.6	24	160
100	19	M	KHANAPUR	19.1	19.1	25.2	25.6	162.5

## MASTER CHART

**Table showing hand length, foot length and stature (height) of both left and right sides of the body in female subjects included in the study.**

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
1	20	F	BELGAUM	15.8	15.4	21.9	22	142.3
2	20	F	BELGAUM	16.4	16.2	23.2	23.4	148
3	19	F	BELGAUM	18	17.9	24.5	23.7	169
4	19	F	BELGAUM	17.4	17.4	24.2	24.2	156.8
5	19	F	BELGAUM	16.7	16.6	24.2	24.2	145
6	18	F	BELGAUM	16.6	16.5	22.9	22.8	138
7	20	F	BELGAUM	17.4	17.6	23.5	23.6	158.8
8	19	F	BELGAUM	18.7	18.6	23.8	23.8	154
9	19	F	BELGAUM	16.8	17	24.2	24.3	154
10	19	F	BELGAUM	16.8	16.9	23.2	23.2	150
11	19	F	BELGAUM	14.4	14.6	22.8	23.4	145
12	19	F	BELGAUM	17.5	17.6	25.6	25.9	160
13	19	F	BELGAUM	16.5	16.5	23.2	23.2	151
14	19	F	BELGAUM	16.2	16.6	23.4	23.4	152
15	19	F	BELGAUM	17	17.1	23.2	23.5	154
16	20	F	BELGAUM	16.8	16.9	23.5	23.6	154
17	19	F	BELGAUM	15	15.2	23.4	23.6	151.5
18	19	F	BELGAUM	15.3	15.5	22	22.2	152
19	19	F	BELGAUM	17	17.2	23.6	23.8	161
20	21	F	BELGAUM	17	17.2	23.2	23.3	152
21	19	F	BAILHONGAL	15.9	16	21.8	22	151
22	18	F	BAILHONGAL	15.2	15.4	22.3	22.8	142
23	20	F	BAILHONGAL	16.6	16.7	23.6	23.7	155
24	20	F	BAILHONGAL	16.1	16.4	24.6	24.7	157
25	20	F	BAILHONGAL	16	16.2	22.3	22.5	149.5
26	20	F	BAILHONGAL	16	16.1	22.4	22.6	144.5
27	20	F	BAILHONGAL	15.9	16	22.2	22.4	144.7
28	20	f	BAILHONGAL	15.3	15.4	22.2	22.3	147.3
29	20	F	BAILHONGAL	16	16.2	22.5	22.7	144.3
30	20	F	BAILHONGAL	16.8	16.9	23.7	23.8	156.3
31	20	F	BAILHONGAL	16.7	16.8	24.5	24.6	162
32	19	F	BAILHONGAL	16	16.2	23.7	23.9	151.5
33	20	F	BAILHONGAL	16.9	17	23.2	23.5	156.3

## ANNEXURE - III

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
34	19	F	BAILHONGAL	15.9	16	24.6	24.6	149.2
35	20	F	BAILHONGAL	16.6	16.7	23.5	23.6	149.2
36	19	F	BAILHONGAL	17.8	17.8	25.2	25.2	162.1
37	23	F	BAILHONGAL	16	16.1	21.2	21.2	147.3
38	20	F	BAILHONGAL	16.5	16.6	22.7	22.7	149.8
39	20	F	BAILHONGAL	15.8	15.9	22.5	22.5	142.8
40	19	F	BAILHONGAL	16.5	16.8	23	23.2	151
41	20	F	HUKKERI	16.2	16.2	23.5	23.5	160.3
42	20	F	HUKKERI	17	17.1	23.7	23.8	152
43	20	F	HUKKERI	18	18	24.2	24.3	165.3
44	22	F	HUKKERI	15.7	15.8	24.1	24.2	147.2
45	20	F	HUKKERI	17.9	18	25.4	25.6	165
46	20	F	HUKKERI	17.2	17.3	23.2	23.6	152.6
47	19	F	HUKKERI	17	17	24.8	24.8	152.2
48	20	F	HUKKERI	15.6	15.7	23	23.2	144.3
49	19	F	HUKKERI	18	18	25.2	25.5	161
50	22	F	HUKKERI	17.6	17.8	24	24.2	162.3
51	25	F	HUKKERI	16.2	16.4	24	24.2	154.2
52	20	F	HUKKERI	16.4	16.9	22	22.2	159.3
53	23	F	HUKKERI	16.3	16.4	23.4	23.5	150.2
54	23	F	HUKKERI	14.9	15	21.4	21.5	147.8
55	21	F	HUKKERI	16	16.2	23.2	23.2	159.2
56	21	F	HUKKERI	15.8	16	23.6	23.6	154.2
57	23	F	HUKKERI	16.4	16.6	23.4	23.8	153.1
58	21	F	HUKKERI	16.8	17	22.8	23	159
59	19	F	HUKKERI	17.2	17.3	22.7	22.9	160.4
60	19	F	HUKKERI	16.7	16.8	24	24.1	156.3
61	24	F	GOKAK	16	16	22.6	22.7	154
62	20	F	GOKAK	15.2	15.4	23.4	23.4	145
63	19	F	GOKAK	15.6	16	22.3	22.3	145
64	19	F	GOKAK	16.8	17	23.1	23.5	155
65	19	F	GOKAK	15.4	16	23.5	23.6	155.2
66	19	F	GOKAK	16.2	16.3	23.6	24	162
67	19	F	GOKAK	16.6	16.6	24.5	24.5	152.5
68	19	F	GOKAK	16.3	16.4	23.2	23.5	154.2
69	20	F	GOKAK	18.4	18.5	25.9	26	152
70	19	F	GOKAK	16.3	16.5	23.2	23.2	162.4
71	20	F	GOKAK	18.3	18.6	25.9	25.9	166.4
72	19	F	GOKAK	16.9	17	23.2	23.2	152

**ANNEXURE - III**

Sl.No.	Age (Years)	Sex	Place	LHL (cms)	RHL (cms)	LFL (cms)	RFL (cms)	STATURE (cms)
73	20	F	GOKAK	16.5	16.6	22.6	22.8	156.3
74	19	F	GOKAK	16	16.3	23.2	23.6	150
75	22	F	GOKAK	16.3	16.5	22.5	22.9	152
76	19	F	GOKAK	17.5	17.6	23.3	23.4	158.3
77	19	F	GOKAK	17.1	17.3	23.2	23.5	154
78	25	F	GOKAK	17	17.2	24.2	24.5	158.2
79	21	F	GOKAK	17	17	23.5	23.6	160.3
80	20	F	GOKAK	17.3	17.6	24.4	24.6	156.8
81	20	F	KHANAPUR	15.9	16.1	23.1	23.2	152.5
82	19	F	KHANAPUR	16	16.2	22.1	22.3	152
83	19	F	KHANAPUR	16.9	17.1	23.2	23.2	156
84	20	F	KHANAPUR	17.5	17.6	23.5	23.6	158
85	18	F	KHANAPUR	17.4	17.5	24.2	24.2	160
86	19	F	KHANAPUR	17.2	17.3	23.4	23.6	157.6
87	21	F	KHANAPUR	16.3	16.4	24.4	24.5	151.5
88	19	F	KHANAPUR	17.4	17.5	24.3	24.6	163
89	18	F	KHANAPUR	17.6	17.8	24.4	24.4	151
90	18	F	KHANAPUR	16.5	16.5	23.5	23.7	153
91	18	F	KHANAPUR	16.8	16.8	23.6	23.7	155.6
92	19	F	KHANAPUR	18	18	24.6	24.7	164.2
93	20	F	KHANAPUR	16.8	17.1	23.6	23.8	152
94	20	F	KHANAPUR	17.4	17.6	24.2	24.5	161.3
95	19	F	KHANAPUR	17.2	17.3	23.2	23.5	150
96	20	F	KHANAPUR	17.5	17.5	24.2	24.2	153
97	21	F	KHANAPUR	17	17	23.5	23.8	158
98	20	F	KHANAPUR	15.8	16	22.7	22.8	152
99	21	F	KHANAPUR	17.1	17.6	23.2	23.5	155
100	20	F	KHANAPUR	18	18.2	25.4	25.6	163