"A STUDY OF "ESTIMATION OF STATURE FROM FOOT LENGTH MEASUREMENTS AMONG HEALTH SCIENCE STUDENTS OF NORTH KARNATAKA REGION-A CROSS SECTIONAL STUDY"

By

Reg No- BF0116002

KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH
Deemed-to-be-University
EMPOWERING PROFESSIONALS

Dissertation

Submitted to the
KLE Academy of Higher Education and Research
Belagavi, Karnataka
In partial fulfilment of the requirements
for the degree of

DOCTOR OF MEDICINE
In
FORENSIC MEDICINE & TOXICOLOGY

JAWAHARLAL NEHRU MEDICAL COLLEGE, BELGAUM.
TRUTH, SERVICE, SACRIFICE

DEPARTMENT OF
FORENSIC MEDICINE & TOXICOLOGY
J. N. MEDICAL COLLEGE, BELAGAVI-590010

APRIL-2019

KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH (KAHER), BELAGAVI KARNATAKA

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This is to certify that the dissertation entitled **"ESTIMATION OF STATURE FROM FOOT LENGTH MEASUREMENTS AMONG HEALTH SCIENCE STUDENTS OF NORTH KARNATAKA REGION- A CROSS SECTIONAL STUDY"** is a bonafide research work done by **Reg No- BF0116002.**

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LIST OF ABBREVIATIONS

Cor Coeff	-	Correlation coefficient
LFL	-	Left foot length
JNMC	-	Jawaharlal Nehru Medical College
Reg Coeff	-	Regression Coefficient
RFL	-	Right foot length
HT	-	Height

ABSTRACT

Background:

Identification of a person is of prime and foremost importance in both civil and criminal cases. Though there are several parameters which help in identifying a person, stature is one of the important parameter as it is an inherent characteristic. Stature is the height of the person in upright position. It is considered as one of the important parameters for personal identification and helps in partial identification of unknown human remains. Estimation of foot length provides important evidence in a crime scene investigation as it helps in estimation of stature of an individual. Estimation of body height from its segments or dismember parts has important considerations for partial identification of living or dead human body or remains recovered from mass disasters.

Objectives: The present study was carried out with the following objectives

1. To estimate stature from foot measurements among health science students hailing from North Karnataka region aged 21 years and above (Districts included are Gulbarga, Bijapur, Gadag, Dharwad, Belagavi, Haveri, and Bagalkot) and

2. To evolve regression equation for estimation of stature from foot length in both male & female, which in-turn will help in partial identification of the individual. .

Methodology: Total of 150 students (75 male and 75 female students) studying in various health science institutions of K.L.E Academy of Higher Education and Research, Belagavi aged 21 years and above were included in the study.

Sampling Method: Preparing a list of students of constituent colleges of K.L.E academy of Higher Education and Research born and brought up in North Karnataka region and from this list randomly picking 15 males and 15 females from each college as there are 5 colleges.

Measurement of Foot length: The foot length was measured independently on right and left side of each individual. The subjects were made to stand on a pre-calibrated Osteometric board with bare footed in such a manner that the posterior point of the heel is gently touched the backrest part of the board. A vertical stop is placed against the anterior most point of foot i,e the tip of hallux or tip of second toe (if toe is larger than hallux). The distance between the posterior most point of the heel (Pternion) and anterior most point (Acropodian) of the foot measured as foot length in centimeters.

Measurement of Height of individual: The stature of the individual is measured by height measuring instrument (Stadiometer) marked in mm, cms and inches. The subjects were asked to stand barefooted in anatomical straight position without support and the arms by the side of the body. The sliding head plate is brought into firm contact with the vertex of the subject. Height of each student was measured in standing erect anatomical position from heel to the vertex of head in centimeters.

All the findings were recorded in a standard proforma.

The measurements were taken at a fixed time between 2 pm to 4 pm to eliminate the possibility of diurnal variation and by only one observer in order to avoid inter-observer error.

Results: A positive and statistically significant correlation between stature and right foot length and left foot length was observed in both the sexes. Regression equations for stature estimation were formulated using right and left foot length separately in both the sexes.

Conclusion: The results indicate that foot length provides an important means in estimating the stature of an unknown individual. There is no statistically significant difference in the stature estimated by right and left foot length in both the sexes.

Keywords: Stature; Foot length; Identification.

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INTRODUCTION

Identification of a person is of prime and foremost importance in both civil and criminal cases. It is a challenging task for investigating officer to make rapid and accurate assessments in identification of an individual in such cases. Sometimes Forensic Pathologists are asked to aid in establishing the partial identification when unknown dead bodies or mutilated human remains are found[1].

Estimation of stature of an individual from the skeletal remains or from decomposed bodies or from the mutilated or amputated limbs or parts of the body has its own importance in personal partial identification. This has turned out to be useful in natural mass disasters like earthquakes, tsunamis, cyclones and man-made mass disasters like aircraft mishaps, bomb blasts, road traffic accidents, railway accidents etc[2]. Height is also a prime importance for estimation of pharmacokinetic framework and assessment of nutritional status. Estimation of stature from measurements of upper limb and lower limb bones has been endeavoured by number of scientists all over the world with varying degree of precision and perfection.

Discovering mutilated remains of human body is not uncommon.

Sometimes the bodies are dismembered with the objective of concealing the identity of the deceased following a crime or to ease the disposal of the body.

Individual identification from mutilated body remains is a challenge to forensic experts. When incomplete skeletal material is available the stature estimation and sex differences are to be made out.

Stature is the height of the person in upright position. It is an important measure of physical identity. Stature is considered as one of the parameters for personal identification and identification of unknown human remains. Estimation of body height from its segments or dismember parts has important considerations for identification of living or dead human body or remains recovered from mass disasters[3].

Many factors like racial, ethnic and nutritional factors play an important role in human development and growth and therefore different monograms become necessary for different populations[4].

Anthropometry is being widely used in medical sciences especially in Forensic sciences for identification of an individual which is an important step in crime investigation. Thus the study of residents of one region is not necessarily applicable to the resident population of other region. Different formulae will be required for calculating the stature for different population[5.]

Though there are several parameters which help in identifying a person, stature of an individual is one of the important parameter, as it is an inherent characteristic. There is an established relationship between stature and dimensions of various parts of the body allowing the Forensic expert to estimate the stature from available data. Many studies have been carried out to estimate the stature from different body parts like arm length, fore arm length, hand and finger length, length of long bones, foot and shoe lengths etc. Linear regression models are widely used to predict height of an individual on the basis of their body parts.

Estimation of foot length provides important evidence in a crime scene investigation as it helps in the estimation of stature of an individual. Significant and positive correlation coefficient has been shown to exist between stature and measurements of foot length. Ossification of bones of foot occurs earlier than that of long bones of lower extremities. Even during adolescent age, the height can be predicted more accurately from foot measurements than long bones of lower limb. Taken together, evidences suggest that relationship between foot length and stature is of practical use in medico legal cases, anthropology and archeological studies; when such evidence is provided to the investigator, it helps to establish the individual's physical description.[1]

Various formulae have been computed in the past using long bones but the accountability of them due to differing ethnicity and other factors like race and nutritional factors is a question[6]. Most often a foot is brought for identification of an individual in mass disasters; natural or manmade, in assault cases where the body could be mutilated to conceal the identity of the victim. In such cases identification may not be complete, but partial identification would be of importance which helps to proceed in further investigation. One such estimate of stature of an individual by measuring foot length is of considerable value in the process of identification. Studies in the past have showed significant correlation between foot dimensions with stature and sex of an individual. It has been observed that dimensions from lower extremity have a greater correlation with the body height than those of the upper extremity[7]. Ossification and maturation of bones of foot occur earlier than the long bones and height would be more accurately predicted from foot measurement as compared to that from long bones[8].

In mid eighteenth century, Topinard developed a mathematical formula for estimating a person's height: maximum foot length divided by 0.15 reveals stature of most individuals[9].

Despite of the relationships between different body parameters that have been determined, it has been emphasized that these vary from population to population and ethnic origin to ethnic origin due to differences in effects of heredity, nutrition, living style, and levels of physical activity[10]. With this present study a good correlation between foot length and the height of an individual could be established. As such a study has not been done in North karnataka region; present study is under taken to confirm that foot length is useful to determine the height of an individual and to evolve a regression equation for the same for this population.

AIMS AND OBJECTIVES OF THE STUDY

1. To estimate stature from foot length measurements among students studying in various health science institutes in the campus of KLE Academy of Higher Education and Research born and brought up in North Karnataka region (Districts included are Gulbarga, Bijapur, Gadag, Dharwad, Belagavi, Haveri, and Bagalkot).

2. To evolve regression equation for estimation of stature from foot length in both male and female, which in-turn will help in partial identification of the individual.

REVIEW OF LITERATURE

IDENTIFICATION

Identification is defined as the determination or establishment of individuality of a person, living or dead. The origin of the word identity is from Latin word, *'idem'* which means 'the same', i.e. identical.[11] It can be complete or partial. Complete identification denotes the absolute fixation of the individuality of aperson. Partial identification is ascertainment of only some facts (e.g. race, sex, age, stature, etc.) about the identity while the others remain still unknown.[12] Identification is more challenging to a forensic specialist in situations of natural disasters like tsunami, floods, cyclones, floods and man-made disasters like railway accidents, aircraft accidents, bomb explosions and in amputated body to conceal the identity.[13] Height, as we know, is also widely applied in the field of pharmacology for measuring pharmacokinetic parameters and estimation of nutritional status. Determination of gender narrows down the 'identity search' by about half, which implies its significance in crime investigation.[14]

The identification of an individual is necessary because of the following reasons:

- The humanitarian and ethical requirement to know as to which person has been passed away
- To establish the fact of death
- To discharge legal claims and obligations in relation to debts and property

- To prove claims for life insurance contracts
- To allow legal investigations, inquests and other tribunals, such as those held by coroners, procurators fiscal, medical examiners, judges and accident enquiries to proceed with a firm knowledge of the identity of the decedent
- To start police enquiries into criminal or suspicious deaths, as the identity of the deceased person is an important factor in facilitating investigations.[15]

STATURE

Stature can be defined as natural height of a person in erect position.[16] Stature has its own prime importance in identifying an individual. There is close relationship, dimensionally, between the different segments of the body and the height of the subject. The height of a dead body may differ from the height during life in either direction, being slightly longer or shorter, though lengthening is much more common. It varies at different times of the day by 1.5 to 2.5 cm. It is less in the afternoon and evening due to reduced elasticity of the inter-vertebral discs and the longitudinal vertebral muscles.

The natural process of senile degeneration causes gradual decrease in stature by about 0.6mm per year on an average, after the age of 30.[17] In addition, the measured height may change a little at different periods after death. Because of the complete loss of muscle tone in the first stage of flaccidity, relaxation at large joints, such as the hip and knee, together with the lost tensioning effect of par spinal muscles on intervertebral discs, the body may lengthen by up to 2-3 cm. Rigor mortis replace the muscle tone, shortening the body and tending to flex the legs a little. When rigor passes off and decomposition sets in, joints become lax. Loss of tension in the

intervertebral discs tends to shorten the spinal column and hence the total height by a centimeter or so.[15]

According to Trotter and Glesser, the average increase is about 2-5 cm.[18]

Estimation of stature of an individual, for identification, from skeletal remains, decomposed bodies or mutilated limbs is very important in natural or man-made disasters and even in case of murders were body is mutilated for concealing the identity of the deceased.

EMBRYOLOGY AND ANATOMY OF FOOT

Embryology of foot[19]

The lower limb buds are formed by proliferation of somatopleuric lateral plate mesoderm in the regions of flank, apparently in response to signals from adjacent somites. Lower limb bud appears in the lower lumbar region at 28th day. On day 33 a rounded cranial part can be distinguished from a more tapering caudal part. The distal tip of the caudal part will form the foot. On day 37 foot becomes distinct. On day 38, a clearly defined foot plate is apparent on the caudal side of the distal end of the bud. On day 44, toe rays are visible in the digital plate of the foot. On day 56, legs are well defined including the toes.

Anatomy of foot [20,21,22]

Human foot is a complex structure adopted to allow orthograde bipedal stance and locomotion and is the only part of the body which is in regular contact with ground. There are 28 separate bones in human foot and 31 joints including ankle joint.

Functionally the skeleton of the foot may be divided into tarsus, metatarsus and phalanges.

Ankle or talocrural region links the leg to terminal segment of the leg that is the foot. It has its own skeleton made up of seven tarsal bones and represents the proximal segment of foot. The backward projecting heel is distinguished from the reminder of the region, generally referred to as tarsus. Five metatarsal bones form the metatarsus. The foot terminates distally in five digits called toes. First toe is called Hallux or big toe and the fifth toe is called the little toe or digitus minimus[22].

Following bones form the foot:

Talus, calcaneus, navicular, medial cuneiform, intermediate cuneiform, lateral cuneiform, cuboid, five metatarsals, proximal and distal phalanges. All articulate with each other.

Tarsus – Seven tarsal bones occupy the proximal half of the foot. The tarsal bones are arranged in proximal and distal rows but medially there is an intermediate tarsal element, the navicular. The proximal row is made up of talus and calcaneus. Long axis of the talus is inclined anteromedially and inferiorly. The distal row contains (from medial to lateral side) medial cuneiform, intermediate cuneiform and lateral cuneiform and cuboid. Collectively, these bones display an arched transverse alignment that is dorsally convex. Medially the navicular is interposed between the head of talus and cuneiforms. Laterally calcaneus articulates with cuboid.

Metatarsals

Five metatarsal bones lie in the distal half of the foot and connect tarsus and phalanges. The metatarsals are miniature long bones and have a shaft, proximal base and distal head. The head articulates with the proximal phalanx.

Phalanges

There are two phalanges in hallux and three in each of the other toe. Occasionally there may be only two phalanges in little toe.

Joints in foot

Talocalcaneal joint, talocalcaneonavicular joint, calcaneocuboid joint, naviculocuneiform joint, cuboidonavicular joint, inter-cuneiform joint, cuneicuboid joint, intermetatarsal joint, tarsometarsal articulation, metatarso-phalangeal articulation, interphalangeal articulation.

Arches

Three main arches are recognized in the foot. They are – medial longitudinal arch, lateral longitudinal arch and transverse arch. Arches of foot have important role in standing, walking and running.

a) Medial longitudinal arch – it is made up of calcaneus, talar head, navicular, three cuneiforms and medial three metatarsals. The bones themselves contribute little to the stability of the arch, where as the ligaments and muscles contribute significantly.
b) Lateral longitudinal arch – it is formed by calcaneus, the cuboid, fourth and fifth metatarsals.

c) Transverse arch – formed by bases of five metatarsals, cuboid and cuneiforms.

The tarsus and metatarsus are arranged to form intersecting longitudinal and transverse arches. Hence, thrust and weight are not transmitted from tibia to the ground directly through the tarsus but are distributed through the tarsal and metatarsal bones to the ends of the longitudinal arches.

Sole of the foot[21]

The subcutaneous tissue in the sole is more fibrous than subcutaneous tissues of rest of the body. Plantar aponeurosis of dense collagen fibers are arranged mainly longitudinally. The muscles of the sole are arranged in 4 layers. The superficial layer consists of 3 short muscles that cover the sole, beneath the plantar aponeurosis. The second layer consists of long tendons of the digits. Third layer consists of short muscles of great and little toes. Fourth layer consists of plantar and dorsal interosei, tendons of peroneous longus and tibialis posterior.

Vascular supply and lymphatic drainage

Skin around the ankle is supplied by anterior and posterior medial malleolar arteries, anterior tibial artery and medial malleolar branches from posterior tibial and fibular arteries.

The main blood supply to the medial side of the heel is from the medial calcaneal branches of lateral plantar artery. The skin of the lateral side of the heel is supplied by calcaneal branches of fibular artery and lateral tarsal artery.

Arterial supply to the skin of foot is derived from branches of dorsalis pedis (direct continuation of anterior tibial artery), posterior tibial and fibular arteries.

The skin covering dorsum of the foot is supplied by dorsalis pedis artery, first dorsal metatarsal artery and with smaller contributions from anterior perforating branch of fibular artery.

Plantar skin is supplied by perforating branches of medial and lateral plantar arteries. The skin of fore foot is supplied by cutaneous branches of common digital artery.

Venous drainage

Cutaneous venous drainage of foot is via dorsal and plantar venous arches which drain into medial and lateral marginal veins.

Lymphatic drainage

Lymphatic drainage is via vessels that accompany the long saphenous vein medially and short saphenous vein laterally and drain via the inguinal lymph nodes.

Cutaneous innervation

The skin covering ankle and foot are innervated by fourth and fifth lumbar and first sacral spinal nerves. Medial side of dorsum of foot is supplied by saphanous nerve, central part by fibular nerve and the lateral part by sural nerve. Plantar aspect and nail beds are supplied by medial and lateral plantar nerves. Heel is innervated by calcaneal branches of tibial nerve.

Ossification of bones of foot

Tarsus

Talus – single ossification centre appears prenatally at 6^{th} month.

Calcaneaus – It is the only tarsal bone which has two ossification centres. Main centre appears prenatally in third month where as the post apophysis appears in sixth year in males and in 8^{th} year in females and fuse at 14^{th} to 16^{th} year respectively.

Navicular – Single ossification centre appears during 3^{rd} year.

Cuboid – Primary ossification centre appears just before birth.

Medial cuneiform – Ossification centre appears during 2^{nd} year.

Intermediate cuneiform – Ossification centre appears during 3rd year.

Lateral cuneiform – Ossification centre appears during 1st year.

Metatarsus

1^{st} Metatarsal bone – Has two centres – one for shaft which appears at 10^{th} week of intra uterine life and other centre appears for base during 3^{rd} year. Both the centres fuse at the age of 17 to 20 years.

2^{nd}, 3^{rd} and 4^{th} Metatarsals – Have two centres – one for shaft which appears at 9^{th} week of intra uterine life and other centre appears in the head during 3^{rd} year. Both the centres fuse at age of 17 to 20 years.

5^{th} Metatarsal bone – It has got three centres, one each for base and shaft which appear at 10^{th} week of intra uterine life and the third centre appears for head at age of 3 to 4 years. All the centres fuse at the age of 17 to 20 years.

Classification of human foot[23]

Minami 1952

T – Type (Tibial type) – first toe is longer than the second**.**

F – Type (Fibular type) – second toe is longer than the first toe.

O – Type (Transitional type) – when both first and second toe are equal in length.

M – Type – Where 3rd toe is taller.

Deformities of foot[24]

Club foot (Talipus Equinovarus) – deformities include

Equinus – foot is fixed in plantar flexion.

Calcaneous – foot is fixed in dorsiflexion.

Varus – Inversion and adduction of foot.

Valgus – foot is everted and abducted at the mid tarsal joints.

Pes Planus – longitudinal arch is flattened.

Pes Cavus – excessively high arched foot.

Splay – the transverse arch is flattened.

Flat foot – Absence of arching of foot so that the sole lies flat upon the ground. It is a normal condition in infants and children and in fat individuals. Connective tissue on the plantar aspect may give the foot a flat appearance; indeed, soft tissues modify its

appearance to varying degrees at all the ages. It may also be seen in anatomical defects of ankle and foot, in paralysis, in arthritis, in trauma etc.

Deformities of toes[24]

a) Hallus Valgus – Lateral deviation of great toe at metatarso-phalangeal joint of great toe.

b) Hallus Rigidus – Stiff big toe due to osteoarthritis of metatarso-phalangeal joint of great toe.

c) Claw toe – Metatarsophalangeal joint is hyper extended and the inter-phalangeal joint is flexed with or without a fixed contracture of either joint.

d) Hammer toe – a fixed flexion deformity of an inter-phalangeal joint of toe usually with callosity over the prominent proximal joint.

e) Others – Extra toe, Supernumerary toe etc.

Functions of foot[20]

1. To support the body in standing and progression.
2. To lever the body forwards and absorb the shock in walking, running and jumping.

ANTHROPOMETRY IN FORENSIC MEDICINE

Alphonse Bertillon, a French police expert, made use of anthropometry in the field of Forensic Medicine by inventing a system of criminal identification based on anthropometric measurements. Bertillon System was based on three fundamental ideas which were, the ease and relative precision with which certain dimensions of

the bone structure of a living individual could be quantify using simply constructed calipers, the fixed state of the bone system from the age of twenty till death, the enormous differences of dimensions present in one living person compared to those in another. Anthropometric characteristics have close relationship with sex, shape and form of an individual. Somatometry (measurements of body i.e. the outermost measurements of the living or dead body) and osteometry (measurements of skeleton) may be considered as two divisions of anthropometry.[25]

UPPER AND LOWER LIMB DIMENSIONS IN ANTHROPOMETRY

The upper and lower limb of human beings have been extensively studied by forensic scientists, physicians, anatomists, anthropologists and numerous other fields for varied reasons of interest. Collation of the size, shape or morphology of the upper and lower limbs have been successfully used in criminal investigations and in the administration of justice in the past. Estimation of pharmacokinetic variables and evaluation of nutritional status depend on accurate measurement of not only body weight but also height.[26]

Various studies have been conducted in this regard and it have provided highly valuable clues regarding the personal identity. As per physical Anthropologist, long bones of the limbs are best to estimate the height of a deceased. Many of previous workers have done this study on cadavers but cadavers cannot represent a population and they are largely of persons who are aged and might have suffered from chronic debilitating diseases, likely to have been dying in an abnormal posture and it may not be possible to straighten the body to get accurate stature measurement.[27]

LITERATURE SURVEY:

In mid eighteenth century, Paul Topinard proposed a simple formula for estimating a person's height; maximum foot length divided by 0.15 reveals stature of most individuals as stated by Robins in an article[28].

There are numerous means to establish stature and their significance lies in the simplicity of measurement, applicability and accuracy in prediction. The work on estimation of stature from foot length was being carried out since long but data pertaining to regional variations are very few with respect to published literature. Height like other phenotypic traits is determined by a combination of genetic and environmental factors. It is sexually dimorphic and statistically more or less normally distributed.

Various studies done earlier on estimation of stature from foot length:

According to a study by Vinay Manjunath Raj et.al (2014) which included 100 healthy subjects (50 males and 50 females) age group between 21-30 years from S.Nijalingappa medical college, Bagalkot, derived a regression equation between foot length and height as S=92.5+3.0 X RFL for right foot length and left foot as S=85.32+3.3 X LFL in males. In females regression equation for right foot length as S=74.27+3.53 X RFL and left foot length as S=73.5+3.56 X LFL[29].

In a study by Karaddi S et.al (2013) which included 100 male medical students at Mahadevappa Rampure Medical College, Gulbarga, Karnataka, India from 1st semester to 5th semester studied the relation between foot length and stature in males and compared stature estimation by right foot length and left foot length and estimated cor. coeff between RFL and stature in males was +0.82 and LFL and stature

in males was +0.80 and derived regression equation in males as Y= 86.9+3.40(RFL) and Y= 112+2.41(LFL).[1]

In a study by Jatti VB et.al (2013) on 184 medical students (91 males and 93 females) aged between 19-25 years at SSIMS & RC Davangere, Karnataka, India, derived a regression equation between foot length and height of an individual and estimated cor.coeff between foot length and stature in males was 0.37 and 0.34 for right and left foot respectively, and for females was 0.47 for both sides and derived regression formula for males as

Y = 88.39+3.27(RFL) & Y = 92.81+3.10(LFL) and for females as

Y = 81.29+3.32(RFL) & Y = 80.90+3.34(LFL). There is a stronger correlation of foot length with respect to stature in females as compared to males[30].

According to a study by Vidyullatha V Shetty (2015) which included 440 medical students (258 males and 182 females) age group ranging between 17-25 years and estimated correlation coefficient between height and foot length as +0.688 in males and 0.587 in females which is highly significant and derived a regression equation for height and foot length as Y=2.738x+100.2 for left foot male, Y=2.74x+100.1 for right foot male, Y=2.66x+96.40 for left foot female, Y=2.66x+96.31 for right foot female[3].

In a study by Girish shiv shankar, Veena vidya Shankar, shailaja shetty on correlation of human height with foot length on 234 subjects (136 males and 98 females) at Ramaiah Medical college Bangalore, observed that there is significant difference in the mean values between right and left length which is statistically significant where p value is <0.001. They concluded height showed a positive

correlation with LFL in males r= 0.196 & in females r= 0.244. Regression equation was derived in males as Y=0.233+0.068xRFL, Y=1.033+0.251xLFL. Similarly in females Y=0.019+0.003xRFL, and Y=1.85+0.241xLFL[31].

In a study by Vijay Kautilya D on south Indians on determination of stature from anthropometry of foot on 300 subjects (150 males and 150 females) aged above 18 years at shri sathya sai medical college Chennai, observed the foot length had statistically significant correlation with the stature and there was no statistically significant difference in the measurement of feet bilaterally. Correlation coefficient was estimated as 0.563 for RFL and 0.550 for LFL in males and 0.657 for RFL and 0.643 for LFL and thus regression equations were derived with which either of the parameter can be calculated when one is present. Regression equation was derived as Ht= 111.0005 ± 0.242 xRFL, Ht=113.73 ± 0.229xLFL in males and Ht= 83.24 ± 0.337xRFL, Ht= 88.305 ± 0.315xLFL in females. The values depicted are comparable and in agreement with the current study[32].

In a study by Tanuj Kanchan, Ritesh G on estimation of stature from foot dimensions among Gujjars of North Indian population comprising of 200 subjects (100 males and 100 females) observed bilateral variation as insignificant for all the measurements except foot breadth in males where in p value is <0.01. The correlation coefficients between stature and foot dimensions were found to be positive and statistically highly significant. The highest correlation coefficient between stature and foot length in males and foot breadth in females indicates that the foot length provides the highest reliability and accuracy in estimating stature of an unknown male foot breadth in a female[7].

In a study by Geetha GN, Swathi on estimation of stature from hand and foot measurements in a rare tribe of Kerala state on 200 subjects (100 males and 100 females) age group between 20-30 years from from Kasargod district observed all the parameters have higher values in males as compared to females and were statistically highly significant where in p value is <0.001. Correlation coefficient in males was 0.554 for RFL and 0.550 for LFL and in females it was 0.417 for RFL and 0.412 for LFL. Using this formula regression equations were derived as Stature = 98.51+0.242xFL in males and Stature=81.978+0.294xFL in females[33].

According to a study by Charnalia VM (1961) showed the significant correlation between height and foot length where correlation coefficient was 0.46.[34]

According to a study by M.R Shende and P. Bokariya (2010) on 391 young subjects (165 males and 226 females) aged between 18 to 22 years from various colleges of Vidharbha region of Maharashtra India and reported a regression equation between foot length and height of an individual and estimated correlation coefficient between height and foot length was 0.755 for males and 0.335 for females. Using this correlation coefficient regression equation was calculated for males as Y=(63.32)±(4.13)x, for females as Y=(78.22)±(1.11)x, and combined as Y=(44.39)±(4.81)x[35].

In a study of correlation of foot length with height by KD Chavan , established that there is a strong positive correlation between height and length of both feet in both sexes. The study consisted of 1000 subjects (500 males and 500 females). The regression equation derived from their study was as follows; formulae: from right foot length Y = 167.9±1.145 (right foot length in cm-24.97), from left foot length Y = 167.9±1.063 (left foot length in cm-25.02), for female: from right foot length

Y = 154.98±3.616 (right foot length in cm-23.28), from left foot length Y=154.98±3.481 (left foot length in cm)[36].

In 2010 Chikhalkar BG, Mangaonkar AA carried out a study on estimation of stature from measurements of long bones, hand and foot dimensions on 300 subjects (147 males and 153 females) age group between 19 to 23 years, at Grant medical college Mumbai. They derived a regression equation between foot length and height of an individual and estimated correlation coefficient between height and foot length as +0.6102. Using this formula regression equation is derived as Y = 79.723+3.65x. They concluded foot length showed the highest degree of correlation in the study[2]. Similar conclusions were seen in other studies by Jaydeep sen et.al.

In a study by Arti L Narde, A P Dongre (2013) on 640 (343 males and 297 females) subjects aged group between 18-23 years at Indira Gandhi medical college Nagpur, observed males have greater mean value of stature as compared to that of females which is similar to our study and derived multiplication factors in males for RFL as 6.29 and LFL as 6.27 and in females for RFL as 6.44 and LFL as 6.43. Linear regression equation were derived for estimation of stature from foot length and foot breadth of right and left sides. For males Stature = 9.01+5.96x RFL and Stature = 8.57+5.96xLFL and for females Stature = 53.0+4.26x RFL and Stature = 53.3+4.23xLFL. They concluded a direct correlation between stature and foot length and foot breadth[5].

According to a study by Patel SM et.al (2007) on 502 medical students (278 males & 224 females) between 17 to 22 years of age belonging to various region of Gujrat, India and reported a regression formula between foot length and height of an individual and estimated correlation coefficient between foot length and height was

+0.65 in males and +0.80 in females. Derived regression equation was Y = 75.45±3.64 (foot length) in males and Y = 75.41±3.43 (foot length) in females. They concluded that is a strong bond between height and foot length and if either of the measurement (foot length or total height) is known, the other can be calculated.[37]

In another study by Utsav Parekh et al in their research on study of relation of stature with foot length among 200 medical students (116 males and 84 females) in natives of Gujarat State, age group between 17 to 21 years and observed mean stature between males and females was statistically highly significant where in ($p<0.001$) and there was statistically no significant difference in the lengths of right and left foot in males and females and there exhibits a strong positive correlation between stature and foot length. Regression equation was derived as Y=74.75+3.42xFL in males and Y=63.62+3.61xFL in females[38].

A study conducted by Suneel Q (1980) to develop a model for reconstruction of height from foot length in an adult population of North west India. Subjects for the study consisted of 1015 (519 males and 496 females) aged group between 17-32 years and observed that the correlation coefficient was + 0.69 for males and + 0.79 for females and p value was <0.01 and derived regression formula for males as Ht = 75.45+3.64xFL and for females as Ht =75.41+3.43xFL. They concluded mean height, foot length and foot breadth was significantly lower in females than their corresponding values for males[4].

A study by Jitendar Kumar et al on 103 subjects (52 males and 51 females)in age group of 21-32 years in Haryana state shows significant correlation between height and left foot length (r=0.969). They concluded the values of all the parameters in case of males are higher than in females and was statistically highly significant

where p value is <0.01. The best correlation with stature is demonstrated by left foot length in all subjects. They derived the regression formula as Y=80.671+3.648xLFL , Y=86.620+3.414xRFL in males, similarly in females as Y=65.194+4.068xLFL , and Y=73.132+3.721x RFL[39].

In a study by Jitender Pratap Singh et al, on stature estimation from the dimensions of foot in females, comprising of 250 females in the age group between 18 to 23 years selected from various visitors to Lady Hardinge medical college & hospital, New Delhi. They observed a statistically significant correlation with stature (p<0.01). Correlation coefficients of the foot length measurements are higher in comparison to foot breadth in females. Regression equation was derived as Y=88.235+2.967xFL[40].

Jaydip Sen and Sheela Ghosh (2008) studied the relationship between stature and feet dimensions among Rajbanshi male and female individuals of North Bengal. The result of the study indicated that females exhibit shorter stature and smaller feet than their male counter parts. It was determined that there was a significant difference in stature, foot length and foot breadth between sexes. Stature, foot length and foot breadth are positively and significantly correlated with each other (P<0.001). The higher correlation coefficient between stature and foot length over that stature and foot breadth points to the fact that foot length, rather than foot breadth is more accurate in estimating the stature.[41]

In 2010 Deopa Deepa carried out a study to estimate the relationship between foot length and stature using simple linear regression equation analysis both in males and females in Uttharakhand. Correlation coefficient was 0.747 for males and 0.664

for females .A good correlation of height was observed with foot length and it was statistically significant where $p<0.001$.[42]

In 2007 Kewal krishan carried out a study on estimation of stature from dimensions of hands and feet in a North Indian Population. Hand length, hand breadth, foot length and foot breadth of 246 subjects comprising 123 males and 123 females ranging in age from 17 to 20 years were taken independently on right and left side of each individual. Linear and multiple regression equations for stature estimation were calculated using the above mentioned variables. The correlation coefficients between stature and all the measurements were found to be positive ($p<0.01$) and statistically significant. The highest correlation coefficient between stature and foot length indicate that the foot length provides highest reliability and accuracy in estimating stature of an unknown individual[43].

In a study by Jain SK, Mathur PN (2016) on 160 (80 males and 80 females) students of medical college Jhalawar aged between 18 to 25 years derived a regression equation between foot length and height of an individual and estimated correlation coefficient between height and RFL as 0.729 and height and LFL as 0.724 in males. Similarly height and RFL as 0.698 and height and LFL as 0.693 in females. Using this formulae stature is calculated in males as Stature = 4.06xRFL+65.458 & Stature = 3.82x LFL+71.845 and in females as Stature =3.25xRFL+81.212 & Stature = 3.39xLFL+77.793[44].

In a study by Dil Islam Mansur, MK Haque on estimation of stature from foot length in Adult Nepalese population comprising of 440 students age group between 17 to 25 years studying in Kathmandu University school of Medical Sciences, Dhulikhel, Nepal observed there is significant correlation coefficient between height

and RFL (r= 0.688, p< 0.01 for male and r= 0.587, p< 0.01 for female), and height & LFL (r=0.689, p< 0.01 for males, and r= 0.589, p< 0.01 for females). They concluded there is a strong positive correlation between height and foot length. The regression equation for height and foot length was found to be Y= 2.378x+100.2 (LFL) of males, Y=2.74x+100.1(RFL) of males, Y=2.66x+96.40(LFL) of females and Y=2.66x+96.31(RFL) of females[13].

According to a study conducted by Gordon and Buikstra (1992) and Ashizawa et.al (1997) used foot length and shoe dimensions in the estimation of stature and observed significant correlation .They estimated stature from dimensions including both foot length and foot breadth were found to be significantly better than those containing only foot length.[45]

Rutishauser (1968) who for the first time showed that reliability of prediction of height from foot length was as high as that from long bones . The results gave correlation coefficients (r) and regression equations for height (y) on foot length (x) calculated from data, together with the S.D of error incurred by using the regression equations as an estimate of height. Data of all the groups estimated were similar (0.90-0.98), indicating highly significant degree of association. Height was calculated from the regression equation by inserting the value of foot length in the equation $Y = a + bx$[46].

Tierney R Burke (2001) did a project work on relationship stature and foot length. He found in his study the relationship between foot length and stature to be 15.2% (range being 13.9 to 16. 7%) and that with shoe size was 17.5% and derived the regression equation as Y=60.424+4.264x[47].

Daniel MT (2005) et all studied sexual dimorphism in foot length proportionate to stature surveying genetically disparate populations and the results showed female foot length to be consistently smaller than male foot length.[48]

Agnihotri AK and Purwar B (2007) et al studied relationship between foot length and stature using linear and curvilinear regression equation. The aim of this study was 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 18– 30 years. General multiple linear regression model was highly significant ($P < 0.001$) and validated with highest values for the coefficients of determination $R_2 = 0.769$ and multiple correlation coefficient $r = 0.877$. Right foot length, sex and age explained for about 77% variations in stature[49].

Zeybek G (2008) et al, found that in males, stature and foot measurements were higher than in females, and the difference between the average measurements was significant. The highest correlation was observed in the right and left foot length in females, males and mix gender groups, when stature and foot measurement relations were evaluated. The lowest correlation was observed in foot width for right foot in all groups but differed in left foot measurements for each group. Gender estimation formula can help determine the gender with 95.6% accuracy via right foot measurements and 96.4% accuracy via left foot measurements.[50]

Atamturk D and Duyar I (2008) studied about the age related factors in relationship between foot measurements and living stature and body weight in 516 individuals. The sample population is divided randomly in two groups. Group 1, the study group, consisted of 80% of sample and remaining 20% were assigned the cross

validation group. In first stage of the study, they produced equations for estimation of stature and weight using stepwise regression technique. Then their reliability was tested on group 2 members. The results showed that the ratios of foot dimensions to stature and body weight change considerably with age and sex.[51]

Ilayperuma I, Nanayakkara BG (2008) et al did a model for reconstruction of stature based on the measurements of foot length. A total of 210 medical students with an age span of 20-23 yrs. were included in the study. They found that the differences of foot length between genders were significant. The positive correlation between height and foot length was observed in both sexes and it was statistically significant. Mean foot lengths for males were significantly larger than that of females for all ages ($P<0.01$), also the average height of males is more than that of females. The results indicate that foot length provides an accurate and reliable means in estimating the stature. Regression equation was derived as for males Ht=79.042+3.59(FL), for females Ht=65.549+3.94(FL), for both Ht=44.107+4.922 (FL).[52]

Mubarak Ariyo Bidmos (2008) studied about the usefulness of metatarsals in estimation of stature in South Africans. The standard error of estimation of stature for metatarsals was lower than that obtained for fragments of long bones and other skeletal elements studied so far for stature estimation in South Africans with exception of intact long bones.[53]

Barnabas Danborno and Abraham Elukpo (2008) did a study on sexual dimorphism in hand and foot length, indices, stature-ratio and relationship to height in Nigerians. The results showed that in all the anthropometric parameters measured or calculated males were significantly higher ($P<0.001$). Significant relationships were

established between hand and foot lengths in both sexes. Multiple linear regression analysis of hand and foot lengths generated predictive equations with statistical significant ability for height prediction. Thus they stated that height could be predicted more accurately from right hand, left hand and foot lengths. When hand and foot were correlated the relationship between hand and foot length was higher in the females than the males, but when hand and foot lengths were compared to height the relationship was stronger in the males than in the females. Multivariate analysis was conducted to see if the height of subjects could be predicted from the lengths of right and left hands and feet. [54]

Giles and Vallandigham, 1991 based upon large U.S Army databases, studied the relationship between foot length and height varies between 14% and 17% from birth to death, by sex among world population. Analysis indicated a quick estimate of height may be made by presuming foot length to be 15.346% in males and 14.926% in females. Regression equation for men Ht=3.447(FL)+82.206,for women Ht=3.614(FL)+75.065[55].

In a study by Sultan G. Sanli, Turkey, was carried out to estimate relationship between hand length, foot length and stature using multiple linear regressions based on sample of adult male and female residing in Adana, Turkey. Sample size was 80 males and 75 females aged 17-23 years; similar to our study.

The all possible multiple linear regression models for both genders were tested and were found to the best model.[56]

SUMMARY OF SOME PUBLISHED FINDINGS ON FOOT LENGTH AS A PROPORTION OF STATURE FOR MEN AND WOMEN[48]

Citation	Population	n	Male foot length as a % of stature	Female foot length as a % of stature
Hrdlicka 1935	Apache	83	14.93	14.58
Hrdlicka 1935	Aztec	84	15.38	14.98
Hrdlicka 1935	Cora	61	15.21	15.08
Hrdlicka 1935	Maricopa	70	15.19	15.20
Hrdlicka 1935	Mohave	71	15.15	14.62
Hrdlicka 1935	Navaho	79	14.66	14.66
Hrdlicka 1935	Otomi	75	15.45	13.73
Hrdlicka 1935	Papago	80	15.07	14.83
Hrdlicka 1935	Pima	83	14.99	14.83
Hrdlicka 1935	Pueblos	183	14.88	14.68
Hrdlicka 1935	Tarasco	80	15.18	14.85
Hrdlicka 1935	Southern Ute	70	15.12	15.16
Hrdlicka 1935	Yuma	34	15.01	14.85
Hrdlicka 1935	Caucasians-Americans	455	14.97	14.42
Robbins 1986	US	527	Right 15.12 left 15.19	Right 14.72 left 14.75
Davis 1990	African-Americans	135	14.7	14.6
Davis 1990	Caucasians-Americans	136	14.3	13.5
Davis 1990	African-Jamaicans	100	15.4	15.2
Davis 1990	Dutch	130	15.3	14.9
Giles and Vallandigham	US Soldiers	8012	15.34	14.92
Barker and Scheuer 1998	Predominantly Caucasian(London)	105	Right footprint:15.22 left footprint:15.18	Right footprint:14.85 left footprint:14.80
Wunderlich and Cavanagh 2001	US Soldiers	784	15.36	15.01

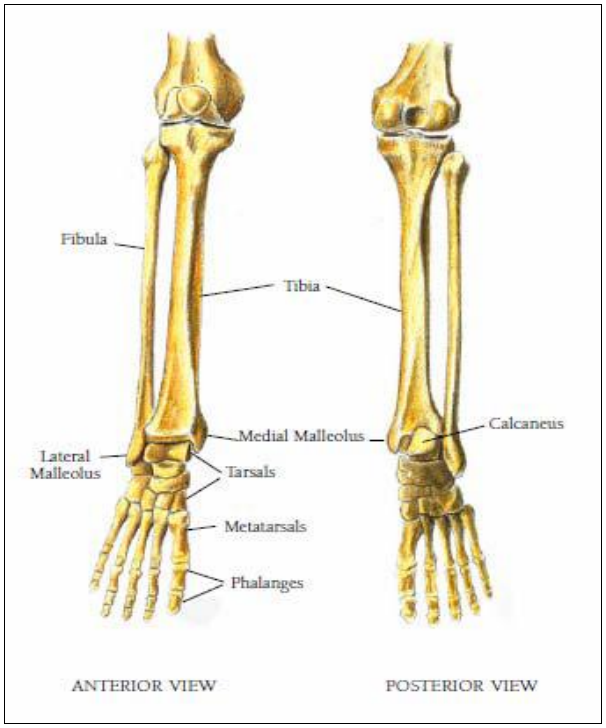

Figure 1: Anterior and posterior view of bones of lower limb[57]

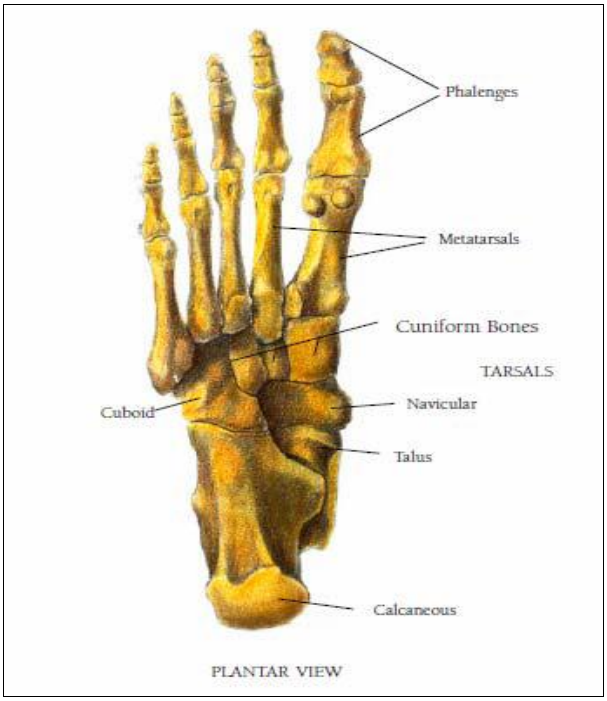

Figure 2: Plantar view of bones of foot[57]

Figure 3: Dorsal view of bones of foot

Table 1: Appearance and fusion of important ossification centers of tarsal bones[58]

TARSAL BONE	APPEARANCE
Calcaneum	5th month(intra-uterine)
Talus	7th month(intra-uterine)
Lateral cunieform	1 year
Intermediate cunieform	3 years
Medial cunieform	2 years
Navicular	3 years
Cuboid	9th month(intra-uterine)

MATERIAL AND METHODS

MATERIALS:

- **Osteometric Board:** This has a rectangular base with a ruler incorporated along one of its long sides. An upright is fixed at one end of the board and a second one slides along the board. Osteometric board is used to measure the foot length on both right and left sides. (Fig.4)

- **Stadiometer:** It is used to measure vertical stature and is graduated in mm, cm and inches with a sliding lever to avoid errors while taking measurements. (Fig.5)

Figure 4: Osteometric Board.

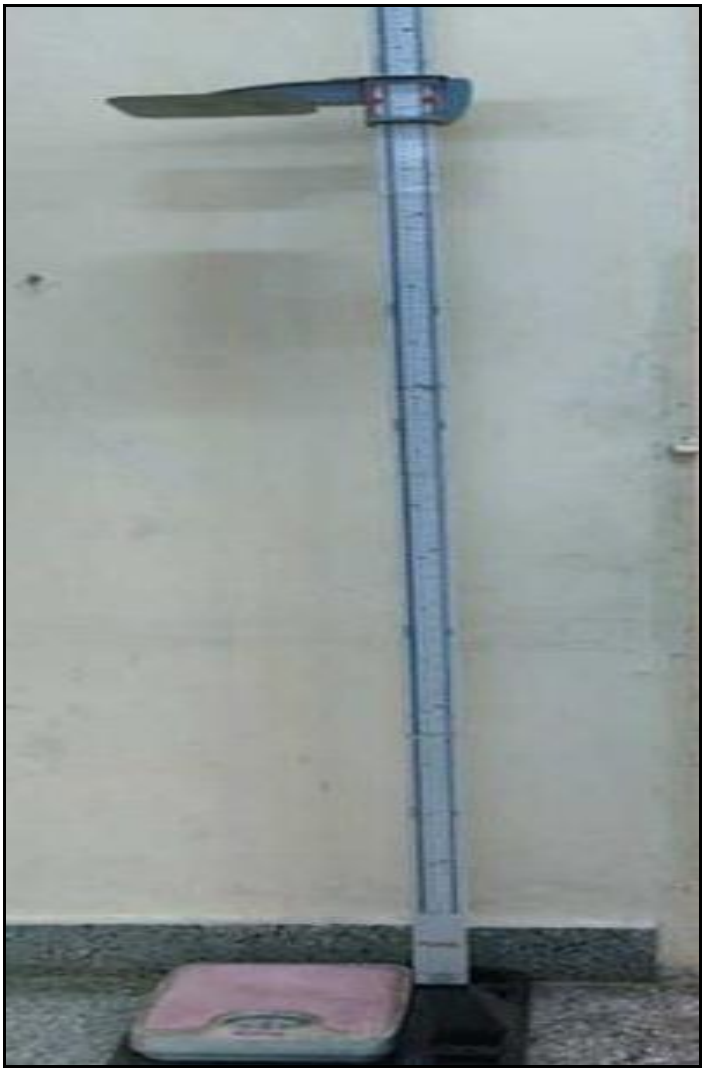

Figure 5: Stadiometer

METHODOLOGY:

Source of Data :

Students studying in constituent colleges of K.L.E Academy of Higher Education and Research Belagavi, aged 21 years and above born and brought up in North Karnataka region.

Sampling Method :

Preparing a list of students studying in various constituent colleges of K.L.E Academy of Higher education & Research belonging to north Karnataka region and from this list proportionate sampling is done.

INCLUSION CRITERIA:

1. Students born and brought up in North Karnataka region (Gulbarga, Bijapur, Gadag, Dharwad, Belagavi, Haveri, and Bagalkot)
2. Students aged 21 years and above (Completion of skeletal growth), studying in constituent colleges of K.L.E Academy of Higher Education and Research, Belagavi.

EXCLUSION CRITERIA:

1. Subjects having skeletal deformities.
2. Cases of gigantism, where the skeletal growth is abnormally high.
3. Cases of dwarfism, where the skeletal growth is abnormally low.

Study Design: Cross sectional study.

Study Period: 1Year 1stJan 2017 to 31stDec 2017

Method of collection of data :

Materials 1) Osteometric Board.

2) Stadiometer.

Sample Size : 150 Students (75 males and 75 females)

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

Taking least correlation coefficient between height and foot length to be 0.335 with α=0.05 and β=0.2, the sample size for study will be

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

$$= \left[\frac{1.96 + 0.84\sqrt{1 - 0.335^2}}{0.335} \right]^2 + 2$$

$$= 69 + 4 = 73 \approx 75$$

75 Males and 75 Females.

r= 0.335, Zα= 1.96, for α= 0.05, Zβ= 0.84, for β= 0.2 Zα and Zβ are standard normal constants.

r is correlation coefficient and n is sample size.

Measurement of Foot length-

The foot length is measured independently on right and left side of each individual. The subjects are made to stand on a pre-calibrated osteometric board with bare footed in such a manner that the posterior point of the heel is gently touched the backrest part of the board. A vertical stop is placed against the anterior most point of foot i.e. the tip of hallux or tip of second toe (if toe is larger than hallux). The distance between the posterior most point of the heel (Pternion) and anterior most point (Acropodian) of the foot measured as foot length in centimetres. (Fig.7,9,10)

Measurement of Height of individual-

The stature of the individual is measured by height measuring instrument (stadiometer) marked in centimetres. The subjects are asked to stand barefooted in anatomical straight position without support and the arms by the side of the body. The sliding head plate is brought into firm contact with the vertex of the subject. (Fig. 6,8)

All the findings are recorded in a standard proforma.

The measurements are taken at a fixed time between 2pm to 4 pm to eliminate the possibility of diurnal variation and by only one observer in order to avoidinter-observer error.

Figure 6: Male Stature Measurement

Figure 7: Male Foot Measurement

Figure 8: Female Stature Measurement

Figure 9: Female Right Foot Measurement

Figure 10: Female Left Foot Measurement

STATISTICAL ANALYSIS:

1. To find out the Correlation Coefficient between height and foot length.

2. Estimate stature from foot length using regression equation.

Data was entered into Microsoft Excel (Windows 7; Version 2007) and analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 18.0; SPSS Inc., Chicago). Descriptive statistics such as mean and standard deviation (SD) for continuous variables, frequencies and percentages were calculated for categorical Variables will be determined. Correlation between Stature and various other parameters in the study was analyzed using Pearson correlation coefficient. Level of significance was set at 0.05.

OBSERVATIONS & RESULTS:

Total 150 health science students comprising of 75 males and 75 females from various colleges of K.L.E Academy of Higher Education and Research aged 21 years and above fulfilling the inclusion criteria were enrolled. Informed consent was obtained by properly explaining them about the objectives of the intended study. For this study direct measurement technique was employed. Foot length was measured independently on right and left side using osteometric board and the stature was measured using stadiometer.

The data for personal height and right foot length for males are shown in Table 1 and the data for personal height and left foot length for males are shown in Table 2.

Table 2. Showing range, mean and SD of height and Right Foot Length for males.

Parameter	Sex	Range (in cms)	Mean	SD
Height	Male	152-188	172.45cms	6.96
RFL	Male	22.5-29.5	25.45	1.40

A linear Correlation Coefficient and regression analysis were done for assessing the relationship between right foot length with stature.

Table 3. Showing range, mean and SD of height and Left Foot Length for males.

Parameter	Sex	Range (in cms)	Mean	SD
Height	Male	152-188	172.45	6.96
LFL	Male	22-29.5	25.35	1.32

A linear Correlation Coefficient and regression analysis were done for assessing the relationship between left foot length with stature.

The Correlation Coefficient for foot length was evaluated as 0.7358 for right foot length males and 0.7304 for left foot length males.

Table 4: Summary of height, right and left foot length, mean, standard deviation, and standard error in male and females.

Variables	Gender	N	Min	Max	Mean	SD	Std Error
Height in cms)	Male	75	152	188	172.45	6.96	0.8
	Female	75	146	171	157.47	5.91	0.68
	Total	150	146	188	164.96	9.89	0.81
Right foot length (in cms)	Male	75	22.5	29.5	25.45	1.4	0.16
	Female	75	20.4	25.1	22.78	1.11	0.13
	Total	150	20.4	29.5	24.11	1.84	0.15
Left foot length (in cms)	Male	75	22	29.5	25.35	1.32	0.15
	Female	75	20	25.4	22.67	1.09	0.13
	Total	150	20	29.5	24.01	1.81	0.15

Table 5: Comparison of males and females with height (in cms), right and left foot length (in cms), mean, standard deviation, standard error and p value.

Variable	Gender	Mean	SD	SE	t-value	P-value
Height (in cms)	Male	172.45	6.96	0.80	14.2192	<0.001
	Female	157.47	5.91	0.68		
Right foot length (in cms)	Male	25.45	1.40	0.16	12.9515	<0.001
	Female	22.78	1.11	0.13		
Left foot length (in cms)	Male	25.35	1.32	0.15	13.5155	<0.001
	Female	22.67	1.09	0.13		

P value is <0.001 which is statistically significant with positive correlation with stature in males and females.

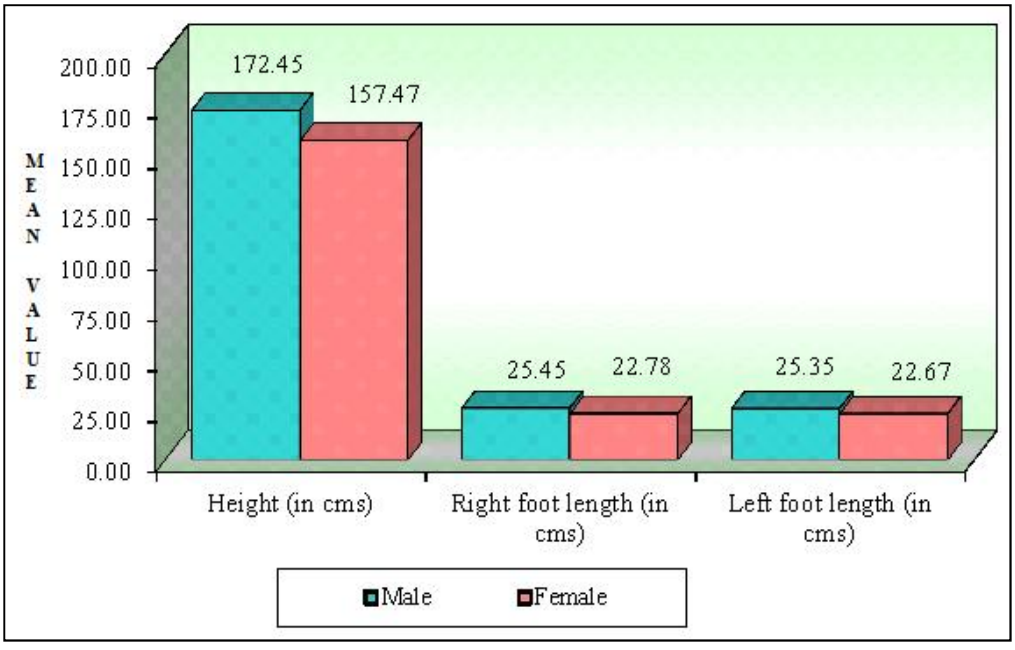

Figure 11 Depicts a bar diagram to compare the mean stature value between males and females. The mean stature is higher for males as compared to females.

Table 6: Correlation between height (in cms), right and left foot length (in cms) by Karl Pearson's product moment correlation coefficient method

Samples	Variables	r-value	r^2	t-value	p-value
Combined	Height vs Right foot length	0.8892	0.7906	23.6396	<0.001
	Height and vs left foot length	0.8882	0.7889	23.5150	<0.001
	Right foot length vs left foot length	0.9769	0.9544	55.6576	<0.001
Male	Height vs Right foot length	0.7358	0.5413	9.2820	<0.001
	Height and vs left foot length	0.7306	0.5338	9.1419	<0.001
	Right foot length vs left foot length	0.9384	0.8805	23.1970	<0.001
Female	Height vs Right foot length	0.7803	0.6089	10.6617	<0.001
	Height and vs left foot length	0.7624	0.5812	10.0661	<0.001
	Right foot length vs left foot length	0.9683	0.9377	33.1443	<0.001

All the parameters exhibited are statistically significant with positive correlation with stature in males, females and combined data studied. Combined data of parameters showed statistically highly significant ($p<0.001$) positive correlation

with stature. Correlation coefficient was ranging from 0.5338 to 0.9544. Correlation coefficient was highest (0.9544) for right foot length vs left foot length in combined data for males and females. Lowest correlation coefficient (0.5338) was obtained for height vs left foot length of males.

It is observed that in the scatter plots as depicted in figures 14 & 15 that the individual values of the parameters have scattered along a straight line demonstrating linear positive relationship of the parameters with the stature.

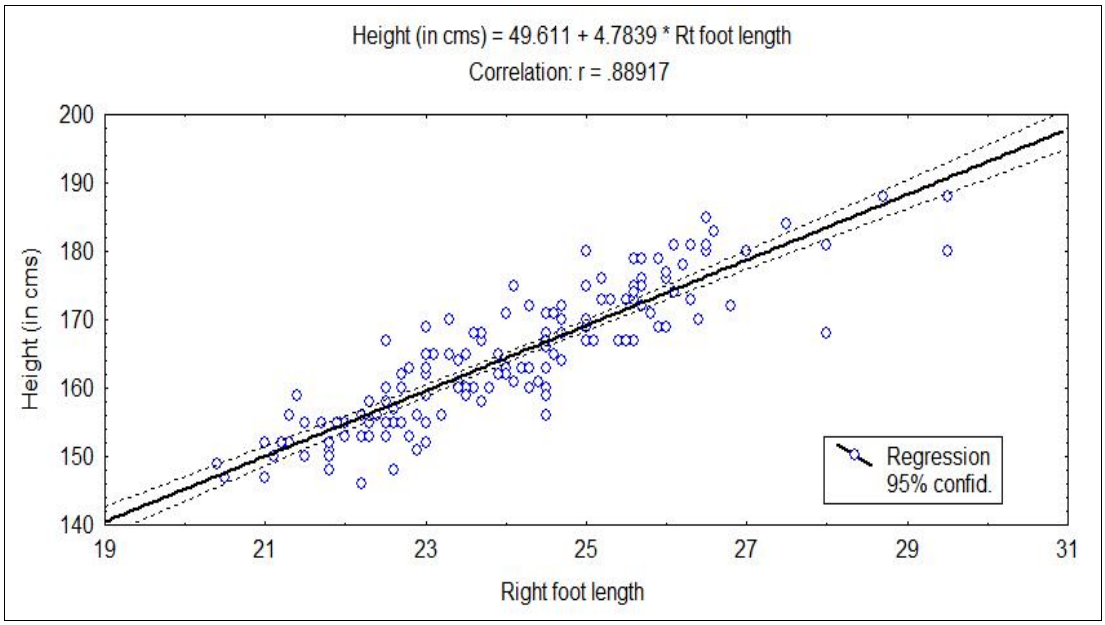

Figure 12: Scatter plot depicting Correlation between height (in cms) and right foot length (in cms) in combined samples

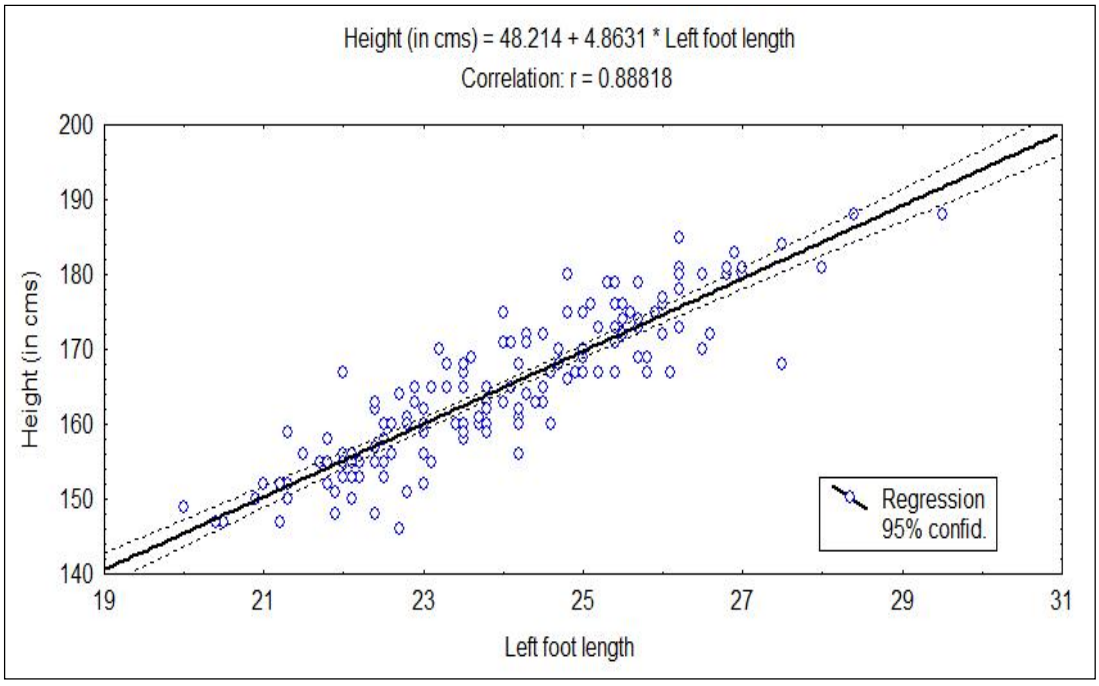

Figure 13: Scatter plot depicting Correlation between height (in cms) and left foot length (in cms) in combined samples

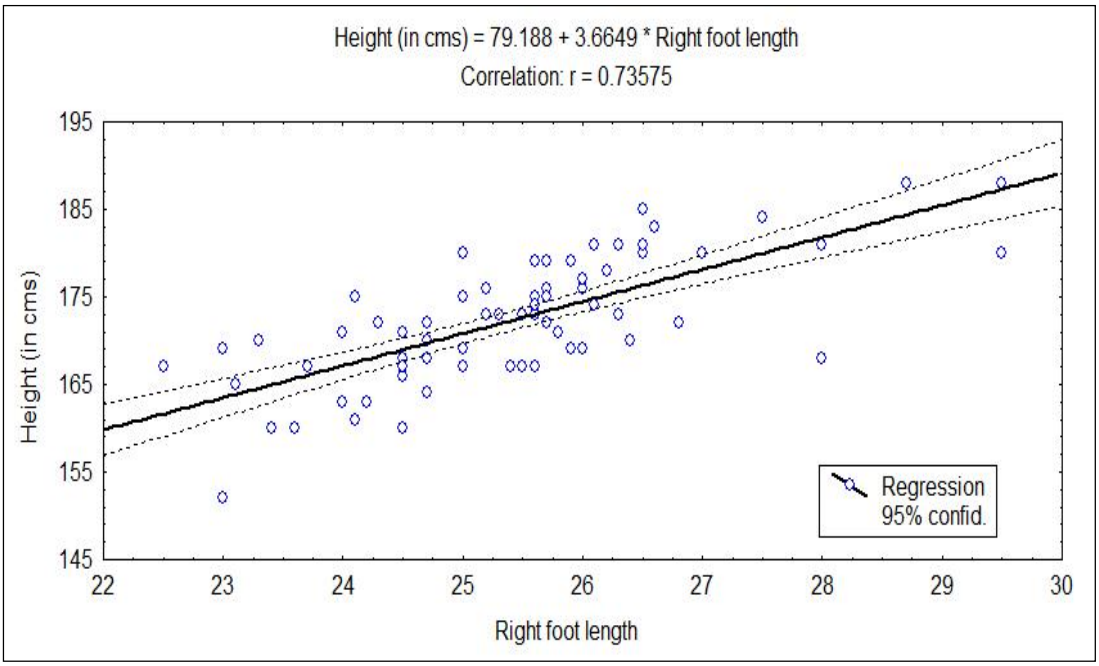

Figure 14: Scatter plot depicting Correlation between height (in cms) and right foot length (in cms) in male samples

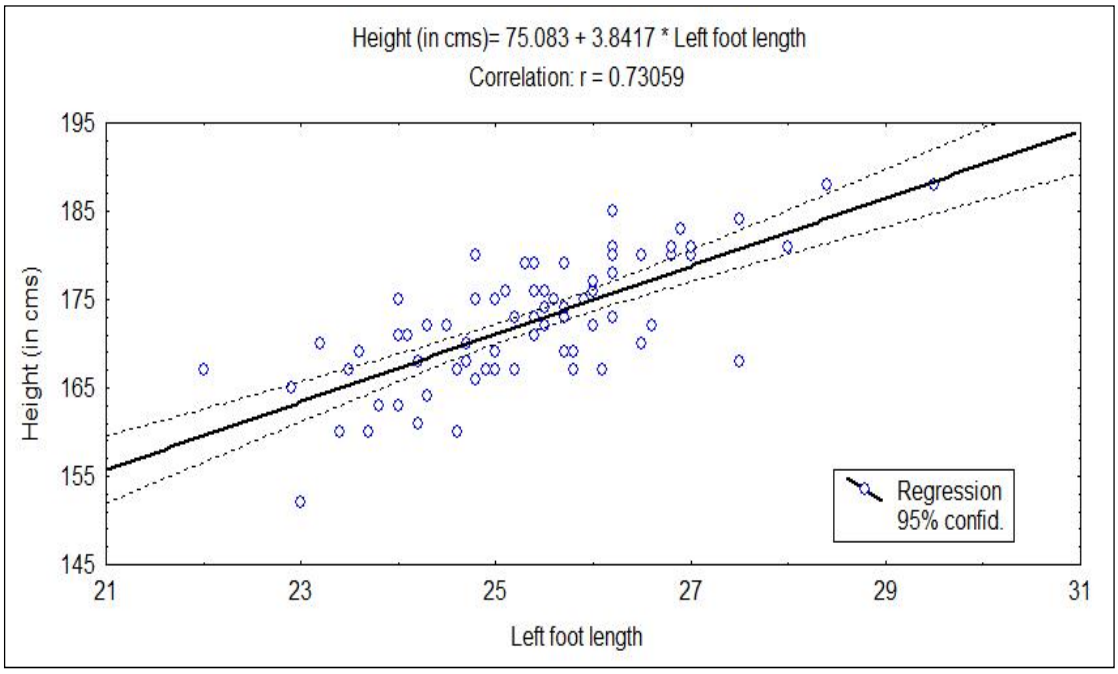

Figure 15: Scatter plot depicting Correlation between height (in cms) and left foot length (in cms) in male samples

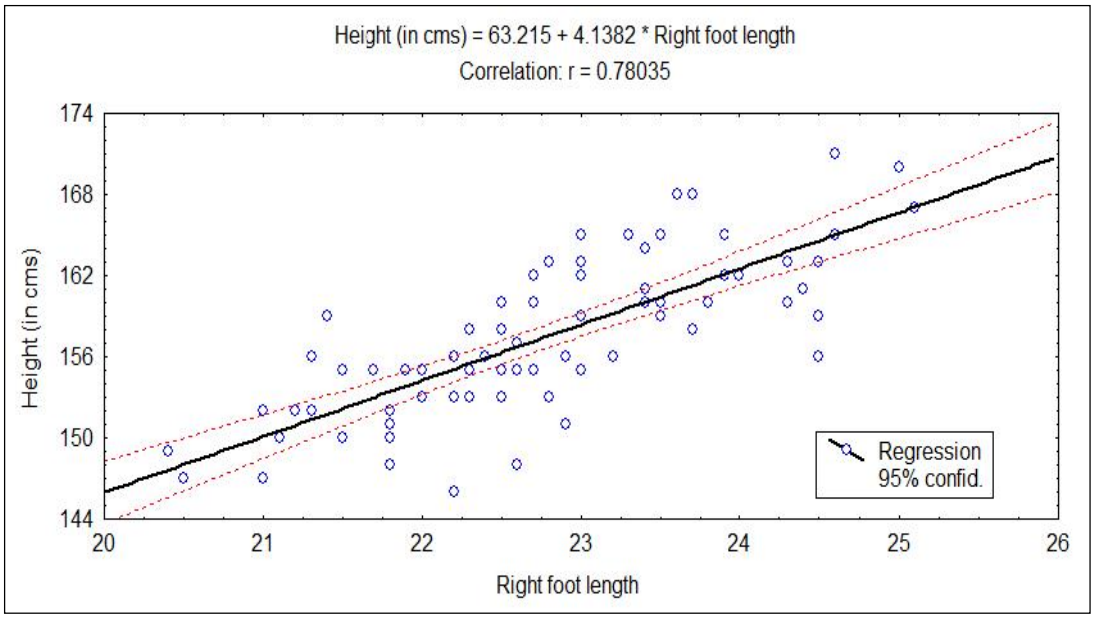

Figure 16: Scatter Plot depicting Corrrelation between height (in cms) and right foot length (in cms) in females samples

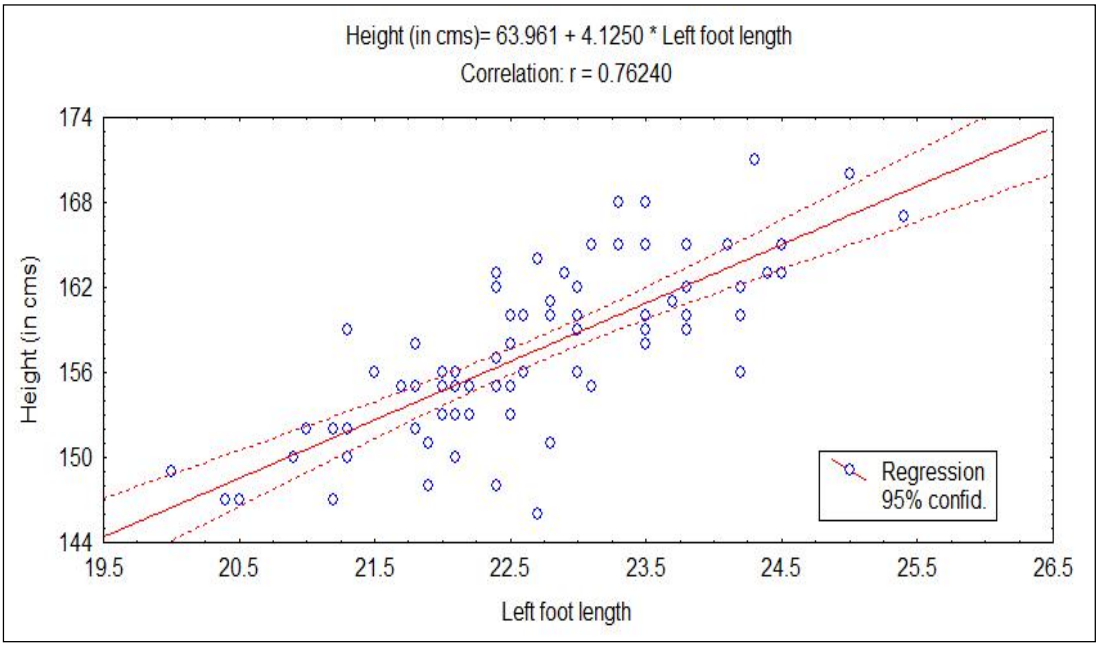

Figure 17: Scatter Plot depicting Corrrelation between height (in cms) and left foot length (in cms) in females samples

Table 7: Simple linear regression of height (in cms) by Right foot length

Samples	Independent variables	Estimates	SE of estimate	t-value	p-level
Combined	Intercept	48.7344	3.9245	12.4181	<0.001
	Right foot length	4.8058	0.1654	29.0587	<0.001
Male	Intercept	79.1884	10.0629	7.8694	<0.001
	Right foot length	3.6649	0.3948	9.2820	<0.001
Female	Intercept	63.2148	8.8507	7.1424	<0.001
	Right foot length	4.1382	0.3881	10.6617	<0.001

Table 8: Simple linear regression of height (in cms) by left foot length

Samples	Independent variables	Estimates	SE of estimate	t-value	p-level
Combined	Intercept	47.8546	4.0124	11.9266	<0.001
	Left foot length	4.8647	0.1699	28.6398	<0.001
Male	Intercept	75.0831	10.6653	7.0399	<0.001
	Left foot length	3.8417	0.4202	9.1419	<0.001
Female	Intercept	63.9613	9.2997	6.8778	<0.001
	Left foot length	4.1250	0.4098	10.0661	<0.001

Table 9: Multiple linear regression of height (in cms) by Right foot length and left foot length

Samples	Independent variables	Estimates	SE of estimate	t-value	p-level
Combined	Intercept	47.1607	3.9211	12.0275	<0.001
	Right foot length	2.7714	0.7976	3.4745	<0.001
	Left foot length	2.1104	0.8099	2.6058	<0.01
	R=0.8933, R^2=0.7980,F(2,221)=436.61 p<0.01, S, Std.Error of estimate: 4.2729				
Male	Intercept	74.3692	10.5007	7.0823	<0.001
	Right foot length	2.0926	1.1332	1.8466	0.0689
	Left foot length	1.7689	1.1963	1.4786	0.1436
	R=0.7448, R^2=0.5548,F(2,72)=44.871, p<0.01, S, Std.Error of estimate: 4.7064				
Female	Intercept	62.5983	9.0603	6.9091	<0.001
	Right foot length	3.5816	1.5642	2.2898	<0.05
	Left foot length	0.5864	1.5959	0.3674	0.7144
	R=0.7808, R^2=0.6096, F(2,72)=56.230 p<0.01, S, Std.Error of estimate: 3.7418				

Table 10: Foot length in males, females and combined data.

	Parameter	Constant	B Coefficient	P Value
Males	Right Foot Length	79.1884	3.6649	<0.001
	Left Foot Length	75.0831	3.8417	<0.001
Females	Right Foot Length	63.2148	4.1382	<0.001
	Left Foot Length	63.9613	4.1250	<0.001
Combined Data	Right Foot Length	48.7344	4.8058	<0.001
	Left Foot Length	47.8546	4.8647	<0.001

Derived Regression Equation:

1. **SM= 79.188+3.6649(RFLM)**
2. **SM = 75.083+3.8417(LFLM)**
3. **SF = 63.215+4.1382(RFLF)**
4. **SF = 63.961+4.1250(LFLF)**
5. **SC = 49.611+4.7839(RFLC)**
6. **SC = 48.214+4.8631(LFLC)**

SM=Stature Males, SF=Stature Females, SC=Stature Combined,

RFLM=Right Foot Length Male, LFLM=Left Foot Length Male,

RFLF=Right Foot Length Female, LFLF=Left Foot Length Female,

RFLC=Right Foot Length Combined, LFLC=Left Foot Length Combined.

Present study aims to estimate stature from foot length measurements of college students of North Karnataka region studying in KLE'S Academy of Higher Education & Research, born and brought up in North Karnataka region. The data was analyzed from 150 students (75males and 75 females), measuring right foot length, left foot length and stature.

To evolve regression equation for estimation of stature from foot length in both male and female, which in turn will help in partial identification of the individual.

Following points can be observed from the present study:

- Male students are taller than female students.
- Mean foot length is more in males than females.
- There is no statistically significant difference in right and left foot length in both the sexes.
- Stature can be determined by right or left foot length separately in both the sexes.
- There is no statistically significant difference in stature estimated by right foot length and left foot length.

DISCUSSION

Most of the time, forensic experts have to deal with unidentified deceased or mutilated remains. In such instances, identification of the deceased or remains is one of the primary and most crucial elements of the investigation. Many factors need to be studied and considered in order to make a positive identification. Determination of sex and stature plays a pivotal role in establishing identity. Half the identity is established when the sex and the stature is acquired.

Clear and comparable biological correspondence is present to the stature with every part of the body. Anthropologists and forensic scientists estimate stature from the measurement of long bone lengths or other parts of the body. For more than a century, anthropometric approach to measure bone length or a part of the body in living and dead have been employed to estimate stature.

Estimation of height from various body parameters have been attempted by many workers .Most of the previous researches have taken single foot into consideration to estimate the stature of an individual[37]. In the present study both right and left foot lengths are taken into consideration to know if there is any significant difference in estimation of stature by right and left foot length separately.

Present study deals with observations on the correlation of height with right foot length and left foot length among health science students of KLE'S Academy of Higher Education and Research, Belagavi, hailing from North Karnataka region.

Age

A study population of 150 subjects, 75 males and 75 females distributed in the age group of 21 years and above were considered. Similarly, other studies done in the past have considered age group that included college students. Different researches and studies have taken different age ranges as the sample population.

Gender

For the current study, 75 males and 75 females were enrolled and the parameters of both the sexes were measured to derive separate regression equation formulae for stature estimation. Many researchers have reported similar studies by maintaining gender equitability with varying standards.

Stature

In the present study, the mean stature of the male is 172.45 cm with standard deviation of 6.96 cm and the mean stature of the female is 157.47 cm with standard deviation of 5.91 cm. The age of puberty is 2-3 years later in males compared to that of females which gives males more time for growth. This explains why the mean stature of male is more than the females and that the formula for one sex cannot be applied for other sex.

Table 11: Stature observed by various researchers

RESEARCHERS	MEAN (SD) MALES	MEAN (SD) FEMALES	MEAN (SD) COMBINED DATA
GN Geetha et al[33]	157.95 (6.42)	148.70 (7.57)	
Vijay Kautilya D et al[32]	172.1 (5.55)	159.4 (5.41)	
Present study	172.45(6.96)	157.47(5.91)	164.96(9.89)

From the above table 10, it is clear that in other studies[32,33] also the male mean stature is more than female mean stature and is in agreement with the current study.

The stature of a living person can be different when compared to the length of the same subject after his/her death. There is also diurnal variation of the stature by 1.5 cm to 2.5 cm. Senile degeneration can cause slow decrease in stature too. The estimated height may vary at different periods after death. In the present study, the measurements were taken at a fixed time of the day in standing erect posture of students aged 21 years and above. In other studies, too, the mean stature of male is observed more than that of the mean stature of females.

Foot Length:

Table 12: Foot length observed by different researchers

Researchers		Mean (SD) Males	Mean (SD) Females	Mean (SD) Combined Data	Correlation Coefficient (p value) Males	Correlation Coefficient (p value) Females	Correlation Coeffient (p value) Combined
Vijay kautilya D et al[32]	RFL	25.42 (1.30)	22.57 (1.05)	-	0.563 (<0.01)	0.550 (<0.01)	-
	LFL	25.67 (2.83)	22.56 (1.10)	-	0.657 (<0.01)	0.643 (<0.01)	-
Jitendra Pratap singh et al[40]	RFL	-	23.60 (1.06)	-	-	0.583 (<0.001)	-
	LFL	-		-	-		-
Chavan KD et al[36]	RFL	24.97 (1.387)	23.28 (1.091)	-	0.63(-)	0.75(-)	-
	LFL	25.02 (1.186)	23.29 (1.108)	-	0.61(-)	0.71(-)	-
Present Study	RFL	25.45 (1.40)	22.78 (1.11)	24.11 (1.84)	0.7358 (<0.001)	0.7803 (<0.001)	0.8892 (<0.001)
	LFL	25.35 (1.32)	22.67 (1.09)	24.01 (1.81)	0.7306 (<0.001)	0.7624 (<0.001)	0.8882 (<0.001)

The mean foot length of males, in the current study, is 25.45 ± 1.40 cm for right side and 25.35 ± 1.32 cm for the left side and the mean foot length of females is 22.78 ± 1.11 cm of right side and 22.67 ± 1.09 cm of left side. The mean foot length of the combined data is 24.11 ± 1.84 cm of right side and 24.01 ± 1.81 cm of left side.

The correlation coefficient of stature with the foot length in male is 0.7358 (right side) and 0.7306 (left side), in female is 0.7803 (right side) and 0.7624 (left side) and combined data is 0.8892 (right side) and 0.8882 (left side) which statistically significant and positively correlated. If the stature of the individual increases or decreases, the foot length also increases or decrease and vice versa. The

mean values of the foot length of the males are more than the females in the other studies depicted.

The study by Vijay Kautilya D et al[32] estimated stature from foot among the south Indians from 300 subjects (150 males and 150 females). The mean foot length of females was less than the males.

KD Chavan et al[36], in their study concluded that the mean foot length in males is more than the females and also there is positive correlation of foot length with the stature with derived regression equations for estimation of stature with the foot length. From the above table it is clear that the mean values are similar to the current study.

Table 13: Linear regression equation for stature with foot length

Researchers		**Regression Equation (Males)**	**Regression Equation (Females)**	**Regression Equation (Combined)**	**P value**
KD Chavan et al[36]	RFL	167.9 + 1.145 (RFLM -24.97)	154.98 + 3.616 (RFLF - 23.28)	-	<0.001
	LFL	167.9 + 1.063 (LFLM - 25.02)	154.98 + 3.481 (LFLF - 23.29)	-	
Vijay Kautilya D et al[32]	RFL	111.0005 ± 0.242 (RFLM)	83.24 ± 0.337 (RFLF)	-	<0.01
	LFL	113.73 ± 0.229 (LFLM)	88.305 ± 0.315 (LFLF)	-	<0.01
Present Study	RFL	79.188+3.6649 (RFLM)	63.215+4.1382 (RFLF)	49.611+4.7839 (RFL)	<0.001
	LFL	75.083+3.8417 (LFLM)	63.961+4.1250 (LFLF)	48.214+4.8631 (LFL)	<0.001

In the present study, to predict stature from the Foot length, the following equations have been derived:

• If sex is known,	For males,	79.188 ± 3.6649 (RFLM)
		75.083 ± 3.8417 (LFLM)
	For females,	63.215 ± 4.1382 (RFLF)
		63.961 ± 4.1250 (LFLF)
• If sex is not known,		49.611 ± 4.7839 (RFLC)
		48.214± 4.8631 (LFLC)

In the present study, the right foot length and left foot length were measured by osteometric board for male and female students. Once the right foot length and left foot length were obtained then by applying linear regression equations the stature is determined. There is no statistically significant difference in the lengths of right foot and left foot.

Average height for each sex within a population is significantly different with adult males on an average being taller than adult females[20]. The results obtained in this study are in agreement with the above statement.

It is stated that the gender difference in height may be attributed to sex chromosomal differences. Adult height between ethnic groups often differs significantly, for example the average height of women from Czech Republic is essentially greater than that of men from Malawai as stated by Ilayperma I[52]. These findings are contradictory to the results obtained in present study where in males are

taller than females. This may be due to effects of heredity, nutrition or lifestyle differences.

Where as Devesh VO (2006)[10], Danborno B (2008)[54] and Vidya CS[59] observed that mean foot length is more in males than in females. The findings are similar to present study.

Vidya CS[59] in her study concluded that left foot is slightly lengthier than that of right foot in both the sexes. In the present study even though there is no statistically significant difference in right and left foot lengths, right foot is slightly lengthier than left foot in both the sexes.

Abraham Philip[60] estimated stature from known foot size by regression method. In the present study regression equations are derived to predict stature separately for right foot length and left foot length for both sexes.

Agnihotri Arun Kumar[49] in his study included 125 male and 125 females students for estimation of stature by left foot length. General multiple linear regression model was highly significant ($P<0.001$) and multiple correlation coefficient was (r) 0.877. In present study where 75 male and 75 female students are included correlation coefficient of 0.7358 and 0.7306 respectively obtained for right and left foot lengths in males and for females it was 0.7804 for right foot length and 0.7624 for left foot length.

Jaydeep Sen (2008)[41] stated in his study that females have shorter stature and small feet than male counterparts. He observed a positive and significant correlation between stature, foot length and foot breadth ($P<0.01$). He concluded that highest correlation between stature and foot length rather than foot breadth points to the fact

that foot length rather than foot breadth is important to estimate stature more accurately. These findings are similar to present study but in present study only foot lengths have been taken under consideration to predict height.

In a study by Devesh V (2006)[10] correlation coefficient (r) of 0.698 for males, 0.738 in females and 0.848 in combined group was obtained between stature and left foot length . In present study, correlation coefficient obtained separately for right foot and left foot in both the sexes. Correlation coefficient is + 0.7358 for right foot length and + 0.7306 for left foot length in males where as in females it is + 0.7804 for right foot length and +0.7624 for left foot length.

The mean height and foot length of males was greater than that of females in Devesh's study which is consistent with present study.

Raju M[61] (2009) obtained a statistically significant relation between bare foot length while walking and stature ($P<0.001$). In his study he included only male individuals. He developed a regression formula for estimating the stature. In our study we included both male and female students. Regression equations are developed separately for right and left foot length in both the sexes. The results are significant.

Deopa Deepa[42] (2010) also observed a significant and positive correlation between foot length and height in individuals of Uttarakhand region.

KD Chavan et al,[36] studied the correlation of foot length with height in Maharashtrian population on 1000 individuals (500 males and 500 females).

There was a strong correlation between stature and height and derived regression equations.

Vijay Kautilya D et al[32] studied on south Indians on determination of stature from anthropometry of foot. The foot length had statistically significant correlation with the stature and thus regression equations were derived with which either of the parameter can be calculated when one is present. The values depicted are comparable and in agreement with the current study. The regression equations derived in various other researchers are depicted in the table (Table 18B) with highly significant P values. The stature can be predicted with close precision with the derived regression equations of the current study.

The results of the present study are quite encouraging and would ultimately help the investigating officer and Forensic experts to estimate stature of a person by foot length. In fact the aim of taking present study was to help the concerned authorities to restrict their field of investigation by including or excluding few subjects from the list of suspects. Investigating officer sometimes depend on the eye witnesses to get rough idea about the height of the person which is not reliable. If foot length is available at the scene of crime stature could be predicted. This study has proved that stature could be predicted by a known foot length.

CONCLUSION:

The present study was done to scrutinise the feasibility of determining the stature of an individual from the ulnar length, the hand length, the tibial length and the foot length by the application of the regression equation. The following deductions were drawn:

- Males exhibit greater dimensions for the foot length and the stature
- The parameters are significantly and positively correlated to the stature.
- The present study observed that there exists sexual dimorphism regarding stature and the parameters.
- The linear regression equations derived from the parameters in the current study can be applied genuinely and reliably for the estimation of the stature.
- Separate regression equations have been derived which we can apply when the gender is known or unknown.
- There exists a population based difference in stature and body dimension proportions and thus necessity of separate regression equations for different regions should be noted.

LIMITATIONS OF THE STUDY:

1. Regression equations developed in the present study may not be applied for estimating height of individuals other than those from Hyderabad

   Karnataka region as the parameters vary from population to population.

2. The present study is not 100% perfect but certainly helps in determination of stature by known foot length with most probability.

3. In certain conditions where there are any congenital or acquired deformities of foot or spine, this study may not be helpful.

4. Diverse constitution of the sample study.

5. Age related stature decline was not taken into consideration

Further scope of the study

1. Split the sample population for derivation of multiple regression equations.

2. Different sample of population can also be included for deriving regression formula

RECOMMENDATIONS

- Results obtained in the present study are statistically significant. Investigating officers and Forensic experts may utilize the findings of present study for estimating an individual's height from foot length as a routine procedure.
- Further studies with larger sample size should be conducted in North-Karnataka Region to confirm the findings of present study.

SUMMARY

- Sample size of the study: 150 subjects (75 males and 75 females)
- Dimensions of stature, and right and left foot length were considered.
- The mean stature of the male is 172.45 cm with standard deviation of 6.96 cm and the mean stature of the female is 157.47 cm with standard deviation of 5.91 cm.
- The mean foot length of male is 25.45 ± 1.40 cm for right side and 25.35 ± 1.32 cm for the left side and the mean foot length of female is 22.78 ± 1.11 cm of right side and 22.67 ± 1.09 cm of left side. The mean foot length of the combined data is 24.11 ± 1.84 cm of right side and 24.01 ± 1.81 cm of left side.

The following are the derived regression equations for estimation of the stature:

Derived Regression Equation:

1. **SM= 79.188+3.6649(RFLM)**
2. **SM = 75.083+3.8417(LFLM)**
3. **SF = 63.215+4.1382(RFLF)**
4. **SF = 63.961+4.1250(LFLF)**
5. **SC = 49.611+4.7839(RFLC)**
6. **SC = 48.214+4.8631(LFLC)**

SM=Stature Males, SF=Stature Females, SC=Stature Combined,

RFLM=Right Foot Length Male, LFLM=Left Foot Length Male,

RFLF=Right Foot Length Female, LFLF=Left Foot Length Female,

RFLC=Right Foot Length Combined, LFLC=Left Foot Length Combined.

Though there are several parameters which help in identifying a person, stature of an individual is one of the important parameter, as it is an inherent characteristic. There is an established relationship between stature and dimensions of various parts of the body allowing the Forensic expert to estimate the stature from available data. Many studies have been carried out to estimate the stature from different body parts like arm length, fore arm length, hand and finger length, length of long bones, foot and shoe lengths etc. Linear regression models are widely used to predict height of an individual on the basis of their body parts. Examination of footprint provides important evidence in a crime scene investigation as it helps in the estimation of stature of a criminal. Significant and positive correlation coefficient has been shown to exist between stature and measurements of foot length.

Many workers have attempted to estimate the stature from different body parameters. The relationship between these body parameters and height varies from population to population. Hence different normograms have become necessary for different populations.

In the present study a significant correlation of stature with right and left foot length has been observed ($P<0.01$). The results show that males are taller and their mean foot length is larger than that of females. There is no statistically significant difference in right and left foot length in both the sexes. Either right or left foot length

may be used to predict the stature by regression formula. Regression equations are derived separately for individual foot length in both the sexes.

Estimation of stature from foot length is easy, economical and convenient. No specialized equipment or training is required. Anthropologists, forensic experts and investigating officers may use this method to their added advantage. Thus this study is able to add another method to estimate the stature from foot length in the individuals of North Karnataka region.

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ANNEXURES

ANNEXURE I: ETHICAL CLEARANCE

K.L.E.UNIVERSITY'S
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)
(Accredited 'A' Grade by NAAC)

Website: http://www.jnmc.edu
E-Mail : deane@jnmc.edu

Phone: (+ 91-(0)831 Office : 2471350
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/ 415 **Date: 17/10/2016**

To,

J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"ESTIMATION OF STATURE FROM FOOT LENGTH MEASUREMENTS AMONG COLLEGE STUDENTS OF NORTH KARNATAKA REGION A CROSS SECTIONAL STUDY "**, is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Arathi Darshan)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Ganga Pilli)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

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ANNEXURE II – PROFORMA

PROFORMA FOR DOCUMENTATION OF DETAILS OF SUBJECTS

I. General Particulars

1 Name :

2 Age :

3 Sex :

4 Address :

5 Nativity :

II. Informed Consent :

Proforma Enclosed

III. Anthropometric measurements

1. Height of the Individual

(from vertex to heel)

2. Foot length : Right : Left :

IV. Any Other Information :

ANNEXURE-III CONSENT FORM

Date:

Time :

I, Mr. / Ms .....aged .....years willingly consent to participate in the dissertation work undertaken by Dr Khaja Azizuddin Junaidi and permit him to take anthropometric measurements (height and foot lengths) and use them for statistical purpose.The procedure has been clearly explained to me and I have understood the same.I have gone through the contents of this form before signing it

Signature of the consenting person

Witness: (Name and signature)

1.

2.

Researcher: (Name and signature)

ANNEXURE IV-MASTER CHART

TOTAL MALE SUBJECTS= 75

SL NO	NAME	RT.F.L(cms)	LT.F.L(cms)	HT(cms)
1	M.U	27.0	26.8	180
2	N.S	25.4	25	167
3	R.D.B	24.3	24.3	172
4	P.M	24.7	24.3	164
5	G.B.R	25.6	25.8	167
6	C.H	25.3	25.2	173
7	M.S.T	25.9	25.8	169
8	K.M.H	25.7	25.4	176
9	S.H	24.5	24.0	171
10	N.G.P	23.6	23.4	160
11	M.S.K	23.3	23.2	170
12	V.N.L	24.1	24.2	161
13	R.S.W	26.2	26.2	178
14	A.G	28.7	28.4	188
15	M.N	28.0	28.0	181
16	P.S.M	24.7	24.5	172
17	S.R.G	25.5	25.4	173
18	A.H	28.0	27.5	168
19	S.J	25.0	24.9	167
20	S.P	25.6	25.3	179
21	S.V.B	26.3	26.2	173
22	S.P	24.7	24.7	168
23	A.C.N	25.7	25.9	175
24	M.P	24.5	24.0	171
25	S.A.M	26.6	26.9	183
26	S.S	26.4	26.5	170
27	V.K	25.0	25.0	169
28	K.V.G	25.0	25.0	167
29	T.S.P	25.6	25.7	173
30	P.B.M	23.7	25.0	167
31	N.B.W	25.4	25.2	167
32	P.B.H	24.0	24.1	171
33	A.D.R	23.4	23.7	160
34	A.A.S	23.1	22.9	165
35	M.V	25.7	25.6	175
36	H.R.S	23.0	23.6	169
37	B.T.C	23.0	23.0	152
38	S.S.A	29.5	29.5	188
39	M.J.S	27.0	27.0	180
40	B.H.M	25.8	25.4	171
41	V.K	26.5	26.5	180
42	S.L	26.0	25.7	169

43	H.S	24.5	24.6	160
44	M.A.M	24.7	24.7	170
45	A.D	25.0	24.8	180
46	R.S	25.6	25.0	175
47	S.J.H	24.1	24.0	175
48	V.H	26.3	26.8	181
49	I.A.S	24.5	24.8	166
50	G.K	23.7	23.5	167
51	P.M.P	26.1	25.5	174
52	N.M.B	26.5	26.2	185
53	P.A	24.0	23.8	163
54	M.U	26.0	25.5	176
55	S.S.S	27.0	27.0	180
56	S.P	22.5	22.0	167
57	M.S.H	25.9	25.7	179
58	A.I	25.7	25.4	179
59	C.M	25.2	25.4	173
60	A.K.K	25.0	24.8	175
61	A.V.P	25.2	25.1	176
62	V.N.K	25.7	26.0	172
63	P.S.C	26.0	26.0	176
64	A.S.C	25.6	25.7	174
65	A.B	27.5	27.5	184
66	S.M.P	26.8	26.6	172
67	S.S	26.1	26.2	181
68	V.C.B	25.5	26.1	167
69	S.L.B	24.5	24.2	168
70	S.K.M.B	24.2	24.0	163
71	V.V.G	26.0	26.0	177
72	A.A	24.5	24.6	167
73	G.S	26.5	27.0	181
74	G.M.M	29.5	26.2	180
75	V.P	25.7	25.5	172

TOTAL FEMALE SUBJECTS=75

SL NO	NAME	RT.F.L(cms)	LT.F.L(cms)	HT(cms)
1	S.S	24.0	23.8	162
2	M.B.P	23.0	23.3	165
3	R.M	24.5	24.5	163
4	M.S.P	23.8	23.8	160
5	S.D	22.7	22.4	162
6	N.P	21.1	20.9	150
7	S.S.D	23.2	23.0	156
8	B.F.S	22.4	22.0	156
9	S.R.K	23.7	23.5	158
10	A.H.S	22.6	22.2	155
11	D.A	23.4	22.8	161
12	S.B	24.5	23.8	159
13	A.K	21.8	21.9	151
14	S.D.B	22.8	22.5	153
15	N.A.S	22.6	22.5	155
16	V.M	20.5	20.5	147
17	S.S.S	23.5	23.5	160
18	P.B.H	22.3	21.8	158
19	M.M.B	22.5	22.5	158
20	A.R.S	23.5	23.5	159
21	A.C	22.5	22.5	160
22	G.J.K	25.0	25.0	170
23	A.A.J.M	23.0	23.0	162
24	P.M	23.5	23.5	165
25	N.P	22.6	22.4	157
26	S.A	24.4	23.7	161
27	A.G	23.3	23.1	165
28	N.R.D	24.6	24.5	165
29	N.S.D	21.5	21.3	150
30	J.K.H	22.0	22.1	155
31	R.P	21.3	21.3	152
32	R.A.K	21.2	21.8	152
33	S.A	21.0	21.0	152
34	A.S.M	22.7	22.4	155
35	P.P	22.9	22.6	156
36	N.M	24.6	24.3	171
37	A.H	22.5	22.1	153
38	U.M.D	23.4	22.7	164
39	V.K	21.0	20.4	147
40	K.D	22.0	22.2	153
41	S.H	21.3	21.5	156
42	A.G	22.8	22.4	163
43	D.R.P	23.0	22.9	163
44	A.K	21.9	21.7	155
45	M.I	25.1	25.4	167

46	S.P	23.0	23.0	159
47	R.R.D	21.7	22.0	155
48	A.J	23.4	23.0	160
49	V.K	24.5	24.2	156
50	S.H	23.9	24.2	162
51	R.J	22.2	22.7	146
52	A.S	21.0	21.2	147
53	E.H.B	22.9	22.8	151
54	D.K	23.9	23.8	165
55	P.S.G	21.4	21.3	159
56	P.S	24.3	24.2	160
57	B.N	22.6	22.4	148
58	A.R.S	22.2	22.1	153
59	R.R.T	22.5	22.5	155
60	K.S	21.8	22.1	150
61	S.M.K	24.3	24.4	163
62	A.B.P	23.7	23.5	168
63	M.M	22.3	22.0	153
64	H.M.K	22.3	22.5	155
65	S.V.K	22.7	22.8	160
66	K.D	22.2	22.1	156
67	D.A.D	24.6	24.1	165
68	R.R.B	21.8	21.2	152
69	N.D	21.8	21.9	148
70	C.D.S	23.6	23.3	168
71	S.S.J	22.7	22.8	160
72	T.P	22.5	22.6	160
73	S.P.S	20.4	20.0	149
74	S.S.B	23.0	23.1	155
75	M.G.N	21.5	21.8	155

ANNEXURES IV - MASTER CHART

TOTAL MALE SUBJECTS=75

SL NO	NAME	RT.F.L(cms)	LT.F.L(cms)	HT(cms)
1	M.U	27.0	26.8	180
2	N.S	25.4	25	167
3	R.D.B	24.3	24.3	172
4	P.M	24.7	24.3	164
5	G.B.R	25.6	25.8	167
6	C.H	25.3	25.2	173
7	M.S.T	25.9	25.8	169
8	K.M.H	25.7	25.4	176
9	S.H	24.5	24.0	171
10	N.G.P	23.6	23.4	160
11	M.S.K	23.3	23.2	170
12	V.N.L	24.1	24.2	161
13	R.S.W	26.2	26.2	178
14	A.G	28.7	28.4	188
15	M.N	28.0	28.0	181
16	P.S.M	24.7	24.5	172
17	S.R.G	25.5	25.4	173
18	A.H	28.0	27.5	168
19	S.J	25.0	24.9	167
20	S.P	25.6	25.3	179
21	S.V.B	26.3	26.2	173
22	S.P	24.7	24.7	168
23	A.C.N	25.7	25.9	175
24	M.P	24.5	24.0	171
25	S.A.M	26.6	26.9	183
26	S.S	26.4	26.5	170
27	V.K	25.0	25.0	169
28	K.V.G	25.0	25.0	167
29	T.S.P	25.6	25.7	173
30	P.B.M	23.7	25.0	167
31	N.B.W	25.4	25.2	167
32	P.B.H	24.0	24.1	171
33	A.D.R	23.4	23.7	160
34	A.A.S	23.1	22.9	165
35	M.V	25.7	25.6	175
36	H.R.S	23.0	23.6	169
37	B.T.C	23.0	23.0	152
38	S.S.A	29.5	29.5	188
39	M.J.S	27.0	27.0	180
40	B.H.M	25.8	25.4	171
41	V.K	26.5	26.5	180
42	S.L	26.0	25.7	169
43	H.S	24.5	24.6	160
44	M.A.M	24.7	24.7	170
45	A.D	25.0	24.8	180
46	R.S	25.6	25.0	175
47	S.J.H	24.1	24.0	175
48	V.H	26.3	26.8	181
49	I.A.S	24.5	24.8	166
50	G.K	23.7	23.5	167
51	P.M.P	26.1	25.5	174
52	N.M.B	26.5	26.2	185
53	P.A	24.0	23.8	163
54	M.U	26.0	25.5	176
55	S.S.S	27.0	27.0	180
56	S.P	22.5	22.0	167
57	M.S.H	25.9	25.7	179
58	A.I	25.7	25.4	179
59	C.M	25.2	25.4	173
60	A.K.K	25.0	24.8	175
61	A.V.P	25.2	25.1	176
62	V.N.K	25.7	26.0	172
63	P.S.C	26.0	26.0	176
64	A.S.C	25.6	25.7	174
65	A.B	27.5	27.5	184
66	S.M.P	26.8	26.6	172
67	S.S	26.1	26.2	181
68	V.C.B	25.5	26.1	167
69	S.L.B	24.5	24.2	168
70	S.K.M.B	24.2	24.0	163
71	V.V.G	26.0	26.0	177
72	A.A	24.5	24.6	167
73	G.S	26.5	27.0	181
74	G.M.M	29.5	26.2	180
75	V.P	25.7	25.5	172

TOTAL FEMALE SUBJECTS=75

SL NO	NAME	RT.F.L(cms)	LT.F.L(cms)	HT(cms)
1	S.S	24.0	23.8	162
2	M.B.P	23.0	23.3	165
3	R.M	24.5	24.5	163
4	M.S.P	23.8	23.8	160
5	S.D	22.7	22.4	162
6	N.P	21.1	20.9	150
7	S.S.D	23.2	23.0	156
8	B.F.S	22.4	22.0	156
9	S.R.K	23.7	23.5	158
10	A.H.S	22.6	22.2	155
11	D.A	23.4	22.8	161
12	S.B	24.5	23.8	159
13	A.K	21.8	21.9	151
14	S.D.B	22.8	22.5	153
15	N.A.S	22.6	22.5	155
16	V.M	20.5	20.5	147
17	S.S.S	23.5	23.5	160
18	P.B.H	22.3	21.8	158
19	M.M.B	22.5	22.5	158
20	A.R.S	23.5	23.5	159
21	A.C	22.5	22.5	160
22	G.J.K	25.0	25.0	170
23	A.A.J.M	23.0	23.0	162
24	P.M	23.5	23.5	165
25	N.P	22.6	22.4	157
26	S.A	24.4	23.7	161
27	A.G	23.3	23.1	165
28	N.R.D	24.6	24.5	165
29	N.S.D	21.5	21.3	150
30	J.K.H	22.0	22.1	155
31	R.P	21.3	21.3	152
32	R.A.K	21.2	21.8	152
33	S.A	21.0	21.0	152
34	A.S.M	22.7	22.4	155
35	P.P	22.9	22.6	156
36	N.M	24.6	24.3	171
37	A.H	22.5	22.1	153
38	U.M.D	23.4	22.7	164
39	V.K	21.0	20.4	147
40	K.D	22.0	22.2	153
41	S.H	21.3	21.5	156
42	A.G	22.8	22.4	163
43	D.R.P	23.0	22.9	163
44	A.K	21.9	21.7	155
45	M.I	25.1	25.4	167
6	S.P	23.0	23.0	159
47	R.R.D	21.7	22.0	155
48	A.J	23.4	23.0	160
49	V.K	24.5	24.2	156
50	S.H	23.9	24.2	162
51	R.J	22.2	22.7	146
52	A.S	21.0	21.2	147
53	E.H.B	22.9	22.8	151
54	D.K	23.9	23.8	165
55	P.S.G	21.4	21.3	159
56	P.S	24.3	24.2	160
57	B.N	22.6	22.4	148
58	A.R.S	22.2	22.1	153
59	R.R.T	22.5	22.5	155
60	K.S	21.8	22.1	150
61	S.M.K	24.3	24.4	163
62	A.B.P	23.7	23.5	168
63	M.M	22.3	22.0	153
64	H.M.K	22.3	22.5	155
65	S.V.K	22.7	22.8	160
66	K.D	22.2	22.1	156
67	D.A.D	24.6	24.1	165
68	R.R.B	21.8	21.2	152
69	N.D	21.8	21.9	148
70	C.D.S	23.6	23.3	168
71	S.S.J	22.7	22.8	160
72	T.P	22.5	22.6	160
73	S.P.S	20.4	20.0	149
74	S.S.B	23.0	23.1	155
75	M.G.N	21.5	21.8	155

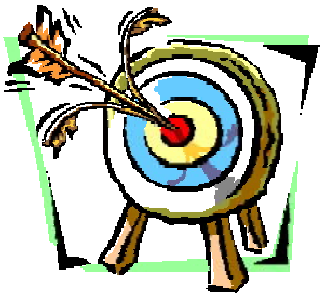
ANNEXURE-V

KEY TO MASTER CHART

RT.F.L- Right Foot Length **HT- Height**

LT.F.L- Left Foot Length

Introduction



Objectives

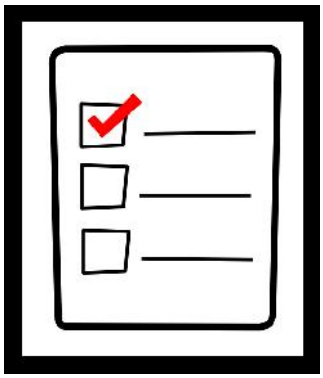
Review of Literature

Methodology

Results

Discussion

Conclusion



Limitations

Recommendations

Summary

Bibliography

Annexures