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St. Paul's Hospital Millennium Medical College

**St. Paul's Hospital Millennium Medical College
Department of Forensic Medicine and Toxicology**

**Estimation of Stature from Lower Limb Anthropometry Measurements among
18-25 years in Addis Ababa, Ethiopia.**

By :Eyob Tsegaye

**Addis Ababa, Ethiopia
April, 2023 G.C**



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April, 2023

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Acronyms and Abbreviations

Acronyms	Extended Form
BMW	Bimalleolar width
MF	Multiple factors
R	Correlation coefficient
SEE	Standard error of estimation
TL	Tibial length
PCTL	Percutaneous tibial lengths
SPHMMC	St. Paul's Hospital Millennium Medical College
SPSS	Statistical Package for Social Science
R ²	coefficient of determination

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Abstract

Background: One of the most crucial characteristics used to identify a person is stature. Forensic scientists will be better able to estimate height from the remains of body parts in forensic investigations and Stature estimation in forensic anthropological and medico-legal investigations has provided extensive information for human identification mainly since the 20th century. Stature can be estimated using either anatomical measurements or mathematical techniques. Stature is estimated based on lower limbs using the mathematical method to produce population-specific formula, especially from the tibia due to fact that it is the longest bones of the human body and contribute directly to stature may clarify this close association. Currently many countries developed population-specific standards for estimating stature. Since these population specific standards (linear regression equations) may not hold true for all population group.

Objective: To develop a formula that predicts height from tibial length, BMW and foot for Ethiopian adults and assess its agreement with measured height.

Methods: An institutional-based cross-sectional, prospective study was carried out among 300 college students in Addis Ababa from December 1 to December 31/2023. G. simple random sampling method was used to select the study participants. Anthropometric measurement including height, tibia length, foot length and bimalleolar width were measured. The data were entered, coded and analyzed using SPSS for windows version 23. And Simple linear regression models were generated for estimation of height from, tibia length, foot length and bimalleolar width parameters.

Result: A total of 300 subjects (150 subjects in each sex) were used. The mean height of study participants was 170.42 ± 4.99 cm for males and 158.75 ± 5.81 for females and 164.59 ± 7.96 cm in combined sexes participants. The Pearson's correlation coefficient between height and all anatomical anthropometric measurements were tibial length (males $R=0.728$, Females $R=0.624$), Bimalleolar width (males $R=0.460$, Females $R=0.488$) and foot length (males $R=0.533$, Females $R=0.744$) and all anatomical anthropometric measurements for both male and female participant showed positive and statistically significant R-value with height with p-value < 0.05.

Conclusion: Stature predicted from tibial length, bimalleolar width and foot length are a valid indicator of height. Out of these tibial length and foot length, for males and females respectively, were appeared to be best estimator of stature by using both RE and R^2 .

Key Words: Stature, tibial length, foot length, bimalleolar width, estimation, linear regression equation.

1. Introduction

1.1 Background

The importance of identification in forensic medicine seems to be paramount. Suicide, bombings, conflict, accidents, earthquakes, and criminal activity are just a few scenarios where identification is required(1,2). When case materials like bone remains and body parts are found, a forensic expert is consulted to provide an opinion on whether the dead may be identified(2). Currently, the big four factors of stature, age, race, and gender are taken into account when creating anthropometrical datasets. These results can verify the identifying process. (1,3).

Stature estimation in forensic anthropological and medico-legal investigations has provided extensive information for human identification mainly since the 20th century(2).

Many various bone dimensions, including those of the upper limb, lower limb, cranium, sternum, portions of the vertebral column, shattered bones, and numerous bones, have been researched for stature estimate.(4). And due to the necessity for population-specific equations, it has been thoroughly investigated in numerous populations. Stature can be estimated using either anatomical measurements or mathematical techniques. When a complete set of skeletal remains is discovered, anatomical techniques are applied(2). The mathematical method is used in special cases, where a body is found dismembered or more than one set of bodies are found. In this study, stature is estimated based on lower limbs using the mathematical method to produce population-specific formula. This study may be beneficial for cases that involve incomplete skeletal remains found in forensic scenarios(2,5).

Since Pearson developed regression equations for height estimate in the 19th century, there has been a great deal of interest in estimating stature from various parts of the human skeleton(2,3,6). This method of stature estimation is based on the relationship between lengths of long bones and stature(2).

The regression equations provided more accurate stature estimation with long bones than with short bones, and it is known that the link between stature and long bones of the lower limb is higher than with the bones of the upper limb, especially the femur and tibia. The fact that they are the longest bones of the human body and contribute directly to stature may clarify this close association (4)

Speaking of racial and ethnic variations arise among populations from different regions. Hence, each ethnic group requires a different forensic standard, for which a region-based study of subjects is necessary and currently many countries developed population-specific standards for estimating stature(7). Since these population specific standards (linear regression equations) may not hold true for all population group, especially those with different genetic ancestry, geographic location, or different socio-economic conditions(8).

1.2 Statement of the Problem

Determining stature is crucial in forensic anthropology as it enables the identification of an individual in criminal cases, missing person cases, and mass fatalities. Stature estimation is a complex task that requires deriving mathematical formulas from the measurements of the skeletal elements(3).

Anthropologists have long been studying the relationship between the different skeletal elements and stature to derive regression formulas that accurately estimate stature. One of the most popular methods of stature estimation is the use of linear regression equations derived from long bone measurements, specifically using the tibia and femur bones. However, an issue that arises is the accuracy of these formulas(2,3).

One of the biggest concerns related to stature estimation using linear regression is the effect of population-specific variation. Several population groups vary in limb proportions, which affects the accuracy of the regression analysis. Linear regression equations derived for one population group may not hold true for another population group, especially those with different genetic ancestry, geographic location, or different socio-economic conditions. This variation can significantly affect the accuracy of the estimation, further hindering the forensic identification process(8).

Another problem that arises in deriving the regression formula for stature estimation is the issue of sexual dimorphism. The differences in bone dimensions and their proportional relationships between males and females have been well-documented. However, estimating stature using regression equations inevitably involves incorporating both male and female data, thereby introducing errors into the calculations(9). In conclusion, deriving a linear regression formula for stature estimation using lower limb dimensions is a complex process that requires the consideration

of many factors. While the use of regression equations based on long bone measurements has gained popularity, the effect of population variation and sexual dimorphism has necessitated more refined techniques. Therefore, it is recommended that forensic anthropologists use multiple regression models and current population-specific data to derive more accurate calculations. This will enhance the reliability of the forensic identification process and help in rendering justice to victims and their families(2,3).

1.3 Significance of the study

Knowing a person's stature, or height, is important in forensic medicine for several reasons. In cases where a person's remains are found, one of the first steps in identification is to estimate the height of the person. This can be compared to missing person reports or other records to help with identification. The lower limbs are an important part of estimating the stature of an individual as they contribute to a significant part of the body length. with accurate measurements and a proper understanding of the anatomy of the lower limbs, forensic anthropologists can accurately estimate the stature of the individual.

One of the advantages of using the lower limb in estimating an individual's stature is because it is less prone to postmortem changes. The femur, for instance, is a long bone that can be measured, and it can offer valuable information regarding the height of the deceased individual. Forensic anthropologists use the length of these bones to compute the estimated height of an individual through various equations.

Apart from the issue of postmortem changes, the lower limb's precision has made it useful in identifying individuals for forensic purposes. Identifying unknown individual from the lower limb bones can be helpful to a forensic investigation since a significant number of cases reported to the authorities are missing persons. so, estimating the stature of the individual from lower limb can provide a significant lead in the investigation. An accurate estimation of the deceased individual's stature can narrow down the list of potential suspects and help authorities identify the victim.

Furthermore, each ethnic group requires a different forensic standard, for which a region-based study of subjects is necessary. Currently no population-specific standards for estimating stature among the Ethiopian population in general and there is also little is known and there are no much published researches done on estimation of stature from lower limb dimensions especially estimation of stature from femur length. Thus, it is quite important to devis our own linear equations to estimate the stature of Ethiopian population from lower limb dimension measurements.

1. Literature review

In medico-legal instances, establishing the personality of ambiguous human remains can be challenging, especially when the body's remaining components are missing or dismantled. This study reviews published works on height, height estimation techniques and the relationships between various anthropometric measurements and stature.

2.1 Methods for estimation of stature

2.1.1 The anatomical method (Fully's method)

Due to its integration of all skeleton components that significantly impact an individual's physical appearance, the Fully's approach to stature estimation was shown to be the most accurate method(10).

Fully's anatomical equation for calculating stature has one major drawback: it does not allow for the extraction of any bone components from the unfortunate casualty, which is a given in mass disasters. It is evident that forensic anthropologists frequently employ the mathematical linear regression method, which is suitable in cases when only bits of human remains have been found(11,12)

2.1.2 The mathematical method

The mathematical method of estimating stature is becoming used today. Its approach for estimating stature involves creating a mathematical regression coefficient based on measurements of the body's segmental length.

2.1.2.1 Correlation of different anthropometric parameters with stature

2.1.2.2 Correlation of tibial length with stature

Several studies have investigated the relationship between tibial length and stature in different populations worldwide, including Africa.

For instance, A high school based cross-sectional study was carried out among 416 High school students in Addis Ababa from May to June 2019 and the author used Stratified multi-stage sampling techniques to select the study participants. Six anthropometric measurement including tibial length was measured and height, arm span and arm length was also measured.

In the study regression models and multiplication factors were generated for estimation of height from anthropometric parameters. and out of the total participants 51.4% were females and 48.6% were males. The mean height of study participants was 164.36 ± 8.89 cm for males and 155.75 ± 5.86 for females. and the simple regression equations computed for prediction of stature from tibial length for male and female subjects was found to be $73.53+2.25(TL)$ and $95.96+1.58(TL)$, respectively. The correlation coefficients (R) of anatomical anthropometric measurements with height were: right tibial length (males $R= 0.738$, females $R= 0.611$), and left tibial length (males $R= 0.744$, females $R= 0.599$). stature predicted from all anthropometric measurements were valid indicator of height. Arm span was appeared to be the best predictor of stature(13).

Similarly, institutional-based, cross-sectional, prospective study was conducted among 572 first year undergraduate students at DMU from April to June 2018. Height, weight, head circumference, head length, inter-acromial length, humeral length, ulnar length, hand length and breadth, tibial length, and foot length and breadth were measured in both sexes. According to the findings, the mean age of study participants was 21.27 ± 1.74 years for males and 20.41 ± 1.58 years for females. The mean height of study participants was 168.36 ± 5.89 cm for males and 165.24 ± 4.01 cm for females and the correlation coefficients (R) of tibial length with height were right tibial length (males $R = 0.634$, females $R = 0.259$), left tibial length (males $R = 0.632$, females $R = 0.258$), simple regression equations computed for prediction of stature from tibial length for male and female subjects was found to be, right side(for males, $125.93+1.15RTL$ and for females, $154.48+0.31RTL$) and left side (for males, $125.93+1.14LTL$ and for females $154.49+0.31LTL$)(14).

likewise, study done on 600 people in the age range of 21 to 45 in the Nigerian state of Cross River, peri-cutaneous tibial length was used to determine height. According to the findings, the mean PCTL for the study's male and female participants, respectively, was 42.55 ± 2.83 cm and 43.60 ± 2.3 cm. The observed heights for the male and female were 165.80 ± 6.88 cm and 156.70 ± 6.06 cm, respectively. It was discovered that for male and female participants, the simple regression equations for predicting height from tibial length were $64.78 \pm 5.289(TL)$ and $23.28 \pm 4.230(TL)$, respectively. the correlation coefficients (R) of tibial length with height was 0.565 for males and 0.507 for females(15).

According to study conducted on 540 randomly selected participants (270 male and 270 female) between the ages of 17 and 21 in the Gwalior region of India found that stature could be statistically calculated from tibial length using simple regression analysis and a multiplication factor. The results showed that the mean tibial length for men was 38.24 ± 2.343 cm, which was significantly ($p < 0.0001$) larger than the mean tibial length for women, which was 36.064 ± 2.464 cm. The mean stature was 164.5 ± 8.257 cm and 155.3 ± 5.854 cm for male and female separately. The relapse model inferred for estimation of stature from tibial length in male was $\text{height} = 105.971 + 1.53 \times (\text{tibial length}) \pm 7.452$ and for female was $\text{height} = 103.76 + 1.43 \times (\text{tibial length}) \pm 4.69$. The multiplication factor was also found to be good in predicting height of the study subjects with, it was 4.302 for male and 4.306 for female. There was huge positive correlation between the stature and tibial length utilizing basic regression and multiplication factor(16).

In another investigation directed on a sum of 240 kids (116 young men and 124 young ladies) of age 3-11 years and having a place with Bengali Hindu standing, stature was seen as significantly connected with age with Pearson correlation coefficient of 0.886 and p-value of < 0.01 and tibial length with Pearson correlation coefficient of 0.856 and p-value of < 0.01 among young men. Essentially, it was emphatically and altogether associated with age with Pearson correlation coefficient of 0.82 and p-value of < 0.01 and tibial length with Pearson correlation coefficient of 0.937 and p-value of < 0.01 among young ladies. The overall sex combined correlations between height and age ($R = 0.855$, p-value < 0.01) and height and tibial length ($R = 0.890$, p-value < 0.01) were all found to be statistically Significant (17).

Another study led by kid inquire about chamber in Denver, report of 67 subjects (31 young Boys and 36 girls) inside the age scope of 3-10 years were utilized. The outcome demonstrated that estimation of stature from tibial length for unknown sex, $\text{stature} = 0.3462(\text{tibial length}) + 39.512(\text{cm})$ with mean tibial length of $230.38 \pm 2.30(\text{mm})$ and coefficient of determination of 0.97. Similarly, the regression model for estimation of stature from tibial length for young boys and young girls' $\text{stature} = 0.3581(\text{tibial length}) + 37.213(\text{cm})$ with mean tibial length of $231.62 \pm 1.73(\text{mm})$ and coefficient of determination of 0.98 and $\text{stature} = 0.3475(\text{tibial length}) + 39.641(\text{cm})$ with mean tibial length of $233.83 \pm 2.57(\text{mm})$ with coefficient of determination 0.97, respectively (18).

In conclusion, the linear regression formula for the estimation of height from tibial length is a valuable tool in medical science. By collecting data on a sample population and using varying sample sizes, age ranges, and regression formulae., it is possible to accurately estimate an individual's height based on their tibial length. The use of this formula can have important applications in the fields of forensic science, and anthropology.

2.1.2.3 Correlation of foot length with stature

Several studies have investigated the relationship between foot length and stature in different populations worldwide, including Africa. Researchers have developed multiple regression equations to obtain the relationship between the two variables, and several different foot dimensions have been used,

For instance, a study in Nepal aimed to estimate the stature of indigenous population using foot measurements amongst adult Nepalese, the researchers collected 440 different foot length and body height measurements and height from students of age group 17 to 25 years, and the result showed the correlation coefficient between height and foot length is + 0.688 in male and + 0.587 in female which is highly significant. It is clear that if either of the measurement (foot length or total height) is known the other can be calculated and this fact may be of practical use in Medico-legal investigations and in Anthropometry(19).

Similarly, An institutional-based, cross-sectional, prospective study conducted by Bickes Wube, Girma Seyoum and Girma Taye on " estimation of stature by anatomical anthropometric parameters in first-year regular undergraduate students at Debre Markos University, Ethiopia" and in the study 572 students and The researchers collected different measurements, including Height, weight, head circumference, head length, inter-acromial length, humeral length, ulnar length, hand length and breadth, tibial length, and foot length and breadth were measured in both sexes and the study concluded with the mean height of study participants was 168.36 ± 5.89 cm for males and 165.24 ± 4.01 cm for females. foot length was significantly correlated with height in both males and females ($p < 0.05$). The correlation coefficient (R) of height with foot length was $R = 0.579$, $R = 0.581$ and $R = 0.185$, $R = 0.186$ in males and females for right and left foot lengths, respectively(20).

A study by Altayeb Abdalla Ahmed (2020) in 100 right- handed Saudi Arabian men aged 18-24 years and six lower limb dimensions were measured bilaterally. And developed regression formulae for stature estimation using different body dimensions, including foot length, and compared the results from different techniques. The researchers concluded that regression formulae developed from foot length measurements showing significant correlations method for estimating the height next to the tibial length and the correlation coefficient for foot lengths were ($r = 0.712$ and 0.700 for the right and left feet, respectively)(21).

In conclusion, the literature review has shown that foot length measurement is a reliable predictor of a person's height in different populations. The use of regression formulae to estimate stature from foot length has been widely researched, and the results provide valuable information for forensic anthropologists, medical practitioners, and other researchers who require height estimation.

2.1.2.4 Correlation of bimalleolar width with stature

A study conducted by Altayeb Abdalla Ahmed in a sample of 160 (80 men and 80 women) Sudanese Arban aged 25-30 years old individuals and four lower limb dimensions were measured. And developed regression formulae for stature estimation using different body dimensions, including Bimalleolar breadth, tibial length, foot length and foot breadth results from different techniques. And The researchers concluded that regression formulae developed from Bimalleolar breadth measurements showing, Stature= $145.56 + 4.28 \times \text{BMW}$ in cm for males and Stature= $126.27 + 5.97 \times \text{BMB}$ in cm for females and also depicting the lowest correlation coefficients were observed for bimalleolar breadth for males ($r=0.349$) and for females ($r= 0.367$) and significant correlations observed from tibial length for both sexes(8).

Similarly, a study conducted on sex and stature prediction among adult Lagmos dwellers using foot anthropometry and done by Nwachukwu Mike Ibeabuchi and his other 4 colleagues on a sample of 222 in Nigerian aged between 18-65 years and found that bimalleolar breadth was a significant predictor of stature, along with other variables such as age, foot length, foot width, navicular height, medial malleolar height and lateral malleolar height and heel breadth with stature. The strongest correlations with stature were observed for right foot width for all groups. The researchers developed a regression equation that included all these variables and showed stature= $147.96 + (4.29) \times \text{BMW}$ in cm for males and stature = $131.48 + (5.6) \times \text{BMW}$ in cm for females and stature= $112.22 + (9.30) \times \text{BMW}$ in cm for combined sexes and correlation coefficients, for males $r=0.269$ and $r= 0.225$ right and left respectively, and for females $r=0.144$ and 0.161 right and left respectively were observed(22).

Overall, the literatures suggests that Bimalleolar breadth can be a reliable and valid method for estimating stature in forensic anthropology. However, it is important to note that BMW measurements should be used in conjunction with other variables and should be validated in the specific population or region of interest.

3. Objectives

3.1 General Objective

- To estimate stature from lower limb anthropometry measurements among 18-25 years in Addis Ababa, Ethiopia.

3.2 Specific Objective

- To investigate the relationship between stature and tibial length, foot length and bimalleolar width.
- To assess gender differences between stature and femur length, tibial length, foot length and bimalleolar width.
- To develop simple linear regression formulas for estimation of stature from tibial length, foot length and bimalleolar width.

4. Research Methodology

4.1. Study Area

The study area for this research paper was Addis Ketema industrial college, located in Addis Ababa, Ethiopia. Addis Ketema Industrial college is a vocational training institution that provides technical education and skills development to students in various industrial fields. The college is situated in Addis Ketema sub-city of Addis Ababa, which is known for its industrial activities. It offers training programs in areas such as electrical technology, automotive technology, metalwork, construction technology, and computer science. Addis Ketema Industrial college plays a crucial role in equipping students with practical skills and knowledge necessary for employment in industrial sector.

4.2 Study Period

- The study was conducted in eight months starting from Dec 1 to Dec 31 2024 G.C.

4.3 Study Design

- An institutional-based cross-sectional, prospective study design was carried out among students of age 18-25 years at Addis Ababa, Ethiopia.

4.4 Study Population

4.4.1 Source Population

- The source population for the study were all adults aged between 18-25 years in Addis Ababa, Ethiopia.

4.4.2 Study Population

- The study population includes all students aged between 18-25 years in Addis Ketema industrial college who met the requirements for inclusion in academic year of 2023G.C.

4.5 Sample size determination

A total of 300 subjects (150 subjects in each sex) were enrolled into this study. This sample size enabled us to detect a correlation coefficient as low as $r = 0.3$ (medium effect size was taken = 0.15) with 95% confidence level, 95% statistical power, number of predictors used were four since there were four independent variables. Sample size was calculated using G-Power version 3.1.9.7 (23,24)

n= is the required sample size

So, the minimum sample size is

$$n=129$$

- ✓ In addition to this non-response rate of 10% were added and the final minimum sample size is 142

4.6 Sampling Procedure

Addis Ketema subcity selected randomly from the 11 subcity which resides in Addis Ababa and Addis Ketema industrial college also selected randomly and simple random sampling method was

employed to select samples that fulfill inclusion criteria so as to get target population (students) who were in age of 18-25 years.

4.7. Inclusion and Exclusion criteria

4.7.1 Inclusion Criteria

- ✓ A health students aged between 18-25 years and those who were willing to take part in the investigation were considered as inclusion criteria for the study.

4.7.2 Exclusion Criteria

- ✓ Participant subjects having spinal and limb deformities which had an effect on standing height and tibial length, such as, bowing of legs and flattening of the plantar arch and having history of significant leg injuries or fractures, Achondroplasia (ACH), or any other congenital or inherited bone illness. physical damage or loss of extremities were considered as excluded from the study.

4.8 Study Variables

4.8.1 Dependent Variable

- ✓ Stature

4.8.2 Independent Variable

- ✓ Age
- ✓ Sex
- ✓ Tibial length
- ✓ Foot length
- ✓ Bimalleolar breadth

4.9 Operational Definitions

- ✓ Stature: the vertical distance between the standing surface and the highest point on the head (vertex) when the subject was standing in the standard standing position.
- ✓ Vertex: is the highest point on the head when the head is in supine position ('Frankfort plane').

- ✓ Tibial length: is a measurement taken from the medial shallowest point on upper border of medial condyle of tibia to tip of medial malleolus of one leg.
- ✓ Bimalleolar breadth: is the distance between the maximum protrusion of the medial and lateral malleoli of the ankle.
- ✓ Foot length: distance from the most prominent part of the heel to the distal part of the longest toe.
- ✓ Frankfurt horizontal plane is a plane connecting the highest point on the upper border of the opening of each external auditory canal and the low point on the lower border of the orbit and that is used to orient a human head in horizontal plane (25) .

4.9 Data Collection Tool and Procedure

The data were gathered through interviewer-administered questionnaire and measurements of anthropometric parameters. Anthropometric measurements were taken at the end of the interview. And three lower limb parameters namely thigh length, Bimalleolar breadth, and foot length were measured. According to the procedure described by the ‘International Biological Program’ measurements from the left side of the body tend to be more reliable than the right side(9). Hence, in this study, the measurements were taken from the left lower limbs for the right-handed and vice-versa. Measurements were performed by one principal investigator, and the measurements were taken two times and average values was taken. The measurements were taken in centimeters (cm), and was measured to two decimal places with accuracy of 0.02mm. And the measurements are taken in the morning so as to avoid diurnal variation. (6)

4.9.1 Landmarks and Techniques used in Taking Anthropometric Measurements

- Height-Vertex (Stature): Stature of the body was measured from the vertex with the head in ‘Frankfort horizontal plane’ to the heel with the body in erect position after removing the shoes.

Instrument: stadiometer

- Tibial length: The subject was asked to be seated and made outward rotating the left foot and measurement taken from upper border of medial condyle of tibia to tip of medial malleolus of left leg.

Instrument: vernier caliper

- Foot Length: The measurement was taken across the dorsum of foot between the two prominences of foot as in preceding measurements, in vertical plane with regard to length.
- Bimalleolar width: measured as the distance between the most medial projection of the medial malleolus and the most lateral projection of the lateral malleolus.

Instrument: vernier caliper (19,26)



Figure 1: Stadiometer

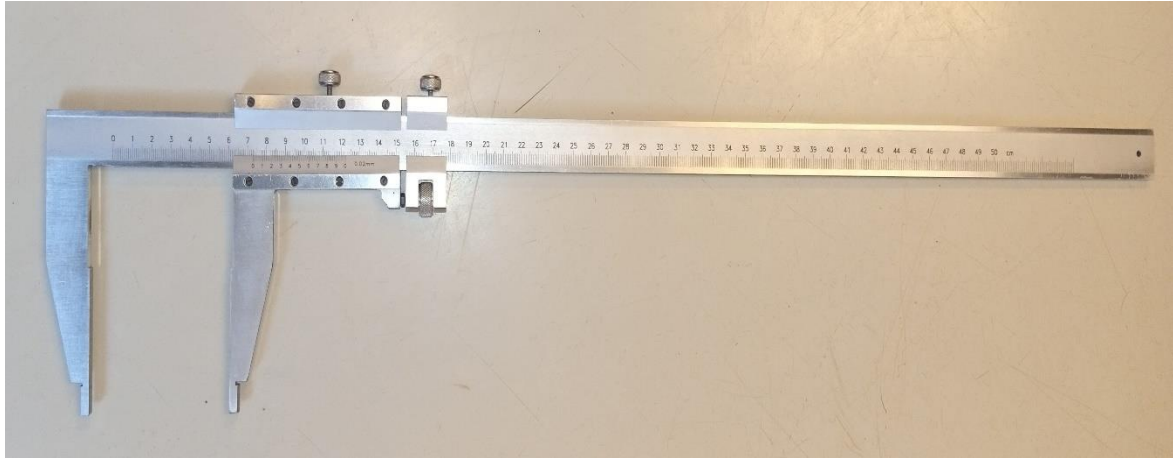


Figure 2: Vernier Caliper



Figure 3:stretched stature measurement (A) and Tibial length measurement(B)



Figure 4:Foot length measurement (C) and Bimalleolar width measurement (D)

4.10. Data Quality control

The data was gathered by the principal investigator. The measurements were taken in centimeters (cm), and was measured to two decimal places with accuracy of 0.02mm. And the measurements are taken in the morning so as to avoid diurnal variation.

4.12 Ethical Clearance

In the beginning, moral ethical clearance was obtained from the Department of forensic medicine and toxicology and St. Paul's Hospital Millennium Medical College Institutional Review Board (IRB) and given a reference number of PM23/890 and verbal informed consent was taken from study subjects and after the information was clarified by principal investigator about the point of the examination and the way that it had no intrusive methodology and damage on the participants. Participants were told to leave the examination whenever they want and they were told that data was recorded without their name being referenced and just codes were used to keep it unknown and keep up secrecy and protection of participants.

4.11 Data Processing and Statistical Analysis

The data were entered, coded and analyzed using SPSS for windows version 23. After appropriate data rechecking, descriptive statistical analysis was conducted and the linear relationship between the stature and the independent variables were checked and the magnitude of relationship was obtained by computing Pearson correlation coefficient(R) and Simple linear regression models was computed to estimate the height of femur length, tibial length, foot length and bimalleolar breadth and. The accuracy of stature prediction of each regression equation was assessed by computing standard error of the estimate (SEE) and coefficient of determination (R).

The regression formula of type, $Y=A+B(X)$, it is a simple regression equation since here x is the only independent variable, where, Y= Height of individual to be estimated, A= Regression constant, B= Regression coefficient, X= length of the long bone (tibia length, foot length and bimalleolar width). The level of significance was set at $p<0.05$.

Before conducting analysis, Statistical test for basic assumption of linear regression includes tests of linearity, tests of homoscedasticity and tests of normality were taken into consideration.

Linearity of the anthropometric variables in the data set was assessed by computing the correlation coefficient and significance of association between the dependent variable (stature) and the independent variables (Tibial length, foot length and Bimalleolar width). The data set showed that the variables are linearly associated for most of the anthropometric parameters with significance of < 0.000 . The next assumption of linear regression considered in the present study was test of homoscedasticity and assessed by generating scatter plot for the residual for dependent variables. Normality of distribution for the remaining anthropometric parameters was checked by establishing histogram plot.

5. Result

5.1 Socio demographic characteristics of the respondents

Table 1 below describes that, a sample of 300 normal, healthy volunteers, aged between 18 and 25, was recruited; 150 of the participants were males and the remaining 150 were females.

Table 1: Socio-demographic characteristics of participants in Addis Ababa, Ethiopia, 2023

SN	Variable	Response	Number	Percent (%)
1	Sex	Male	150	50
		Female	150	50
2	Age in full year	18	13	4.3
		19	51	17
		20	61	20.3
		21	64	21.3
		22	48	16
		23	36	12
		24	16	5.3
		25	11	3.7
3	Handedness	Right	286	95.3
		Left	14	4.7

5.2 Descriptive statistics of anthropometric parameters in male and female aged between 18 to 25 years.

Descriptive statistics for stature/standing height and anatomical anthropometric measurements of male participant is provided in table 2. In the present study it was observed that standing height of study participants ranged from 153 cm to 187cm and the mean ($\pm$ SD) of height was 170.42 ± 4.99 cm in male study participants.

Table 2: Descriptive statistics of stature and anatomical anthropometric parameters of male participants in Addis Ababa, Ethiopia, 2023

Parameters	Minimum	Maximum	Mean	Standard deviation (SD)
Height(cm)	153.00	187.00	170.42	4.99
Tibial length(cm)	33.63	45.73	40.01	2.16
Bimalleolar width(cm)	5.83	7.96	6.86	0.43
Foot length(cm)	22.44	27.76	24.83	1.09

Descriptive statistics for Standing height and anatomical anthropometric measurements of female participant is provided in table 3. In the present study it was observed that height ranged from 146 cm to 169 cm and the mean ($\pm$ SD) of height was 158.75 ± 5.81 cm in female participants.

Table 3: Descriptive statistics of stature and anatomical anthropometric measurements of female participants in Addis Ababa, Ethiopia, 2023

Parameters	Minimum	Maximum	Mean	Standard deviation (SD)
Height(cm)	146.00	169.00	158.75	5.81
Tibial length(cm)	31.84	41.35	36.87	2.06
Bimalleolar width(cm)	5.60	7.61	6.20	0.44
Foot length(cm)	20.66	25.04	22.96	1.13

Descriptive statistics for height and anatomical anthropometric measurements of combined sexes of male and female participant is provided in table 4. In the present study it was observed that height ranged from 146 cm to 187 cm and the mean ($\pm$ SD) of height was 164.59 ± 7.96 cm in combined sexes participants.

Table 4: Descriptive statistics of stature and anatomical anthropometric parameters of combined sex of male and female participants in Addis Ababa, Ethiopia 2023

Parameters	Minimum	Maximum	Mean	Standard deviation (SD)
Height(cm)	146.00	187.00	164.59	7.96
Tibial length(cm)	31.85	45.73	38.45	2.63
Bimalleolar width(cm)	5.60	7.97	6.53	0.55
Foot length(cm)	20.66	27.76	23.90	1.45

5.3 Anthropometric parameters and Stature difference between male and female participants

An Independent sample t-test was generated to illustrate anthropometric parameters and stature differences between male and female participants. Table 5 describes a comparison of the mean value of anatomical anthropometric measurements and stature between male and female participants. In the present study, it was evident that the overall mean value of height and most of the anatomical anthropometric measurements of male participants were found to be greater than that of their female counterparts. and all these differences were statistically significant with p-value <0.05.

Table 5: Comparison of means of all measurements between male and female participants

Independent t-test for equality means					
Parameters	T	DF	Sig(2-tailed)	Mean Difference	Std. Error Difference
Height	15.038	298	0.000	11.670	0.626
Tibial length	0.073	298	0.000	3.140	0.244
Bimalleolar width	0.848	298	0.000	0.668	0.050
Foot length	0.58	298	0.000	1.866	0.128

5.4 Anthropometric parameters and handedness of male and female participants

An Independent sample t-test was generated to illustrate anthropometric parameters and handedness between male and female participants. Table 6 describes a comparison of anatomical anthropometric measurements and handedness of male and female participants. In the present study, it was evident that there is a statistically insignificant difference between handedness and anthropometrics measurements in both male and female study participants at significance of >0.05 .

Figure 6: Handedness of all measurements of male and female participants

Independent t-test				
Parameters	F	DF	Sig(2-tailed)	Std. Error Difference
Height	1.234	298	0.904	2.184
Tibial length	0.407	298	0.362	0.721
Bimalleolar width	3.156	298	0.817	0.150
Foot length	0.823	298	0.987	0.398

5.5 Correlation between standing height and anatomical anthropometric parameters

Pearson's correlation coefficient (R) between height and anatomical anthropometric measurements for male and female participants is provided in Table 7. The Pearson's correlation coefficient between height and all anatomical anthropometric measurements of male participant ranged from 0.460 for bimalleolar width to 0.728 for tibial length and also R-value of female adolescents ranged from 0.488 for bimalleolar width to 0.744 for foot length.

All anatomical anthropometric measurements for both male and female participant showed positive and statistically significant R-value with height with p-value < 0.05 . For both males and females, the lowest correlation was depicted in bimalleolar width. However highest correlation was exhibited in tibial length for male participant and the highest was exhibited in foot length for female participant respectively. With the exception of the R-value for tibial length, all anatomical anthropometric parameters showed higher R-values in female participants compared to male participants.

Table 7: Correlation of height with anatomical anthropometrics of male and female participants in Addis Ababa, Ethiopia 2023

	Male-150		Female- 150	
Parameters	Stature		Stature	
	R	P-value	R	P-value
Tibial length(cm)	0.728	0.000	0.624	0.000
Bimalleolar width(cm)	0.460	0.000	0.488	0.000
Foot length(cm)	0.553	0.000	0.744	0.000



Figure 5: Scatter plot between height and tibial length of male participants in Addis Ababa, 2023

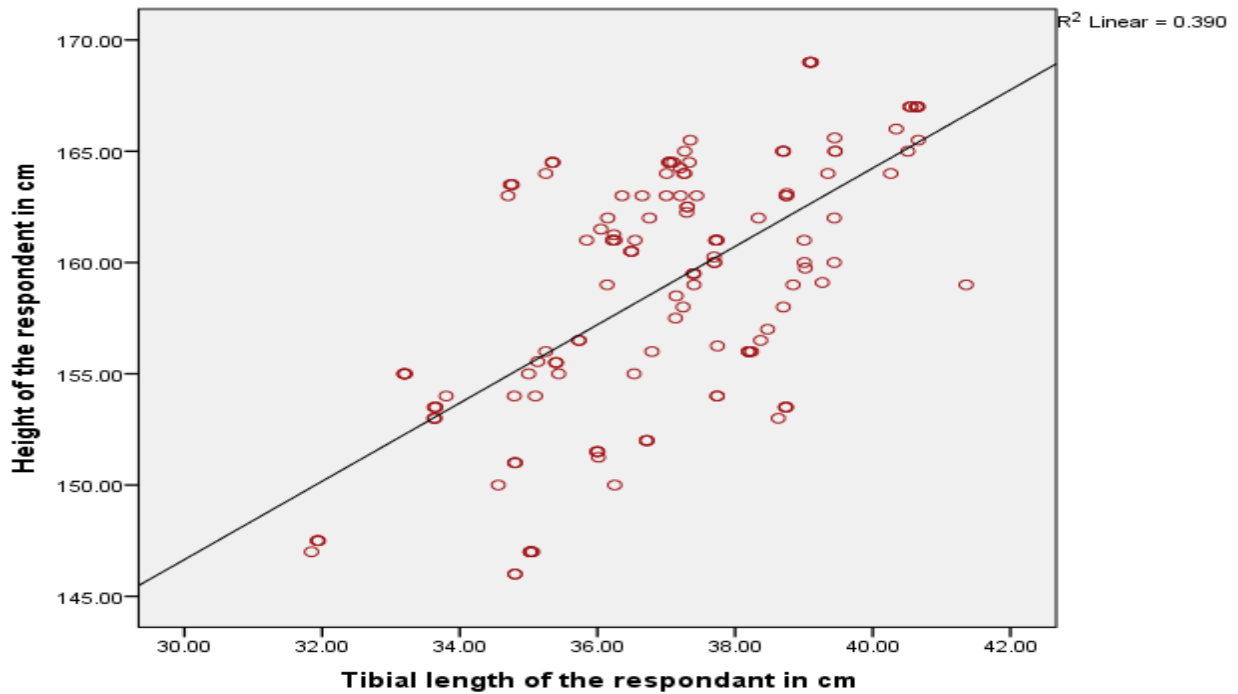


Figure 6: scatter plot between height and tibial length of female participants in Addis Ababa, 2023

The fit regression line showed the relationship between height and tibial length for male and female participants respectively with dispersion from the line at R^2 linear = 0.530 for male and R^2 linear = 0.390 for female participant (Figure 3 and 4).

5.4 Stature estimation from anatomical anthropometric parameters

Simple linear regression models were separately generated for male and female and combined sex participants to estimate stature from different anatomical anthropometric parameters.

5.4.1 Simple linear regression equations to estimate of stature from anatomical anthropometric parameters for male participants

Simple linear regression equations were generated and provided in table 9 for each anatomical anthropometric measurement to estimate height for male participants. The Pearson correlation coefficient was largest in tibial length and smallest in bimalleolar width. Whereas the smallest standard error of estimate (SEE) value was observed in tibial length and largest value was in bimalleolar width. Simple regression equations computed to estimate stature for male participants using Tibial length was Height = 103.27 + 1.68(Tibial length) with R= 0.728 and using Bimalleolar width was Height = 133.69 + 5.35(bimalleolar width) with R= 0.460. All the anthropometric parameters significantly estimated the standing height of the participants with significance of $P < 0.000$.

Table 9: Estimation of stature from anatomical anthropometric parameters of male participants in Addis Ababa, Ethiopia 2023

Parameters	R	R^2	SEE	Regression equation	Sig.
Tibial length(cm)	0.728	0.530	3.437	103.27 + 1.68(TL)	.000
Bimalleolar width(cm)	0.460	0.212	4.452	133.69 + 5.35(BMW)	.000
Foot length(cm)	0.553	0.306	4.176	107.698 + 2.53(FL)	.000

TL-tibial, BMW- bimalleolar width, FL-foot length, R-correlation coefficient R^2 -coefficient of determination and SEE- standard error of estimate

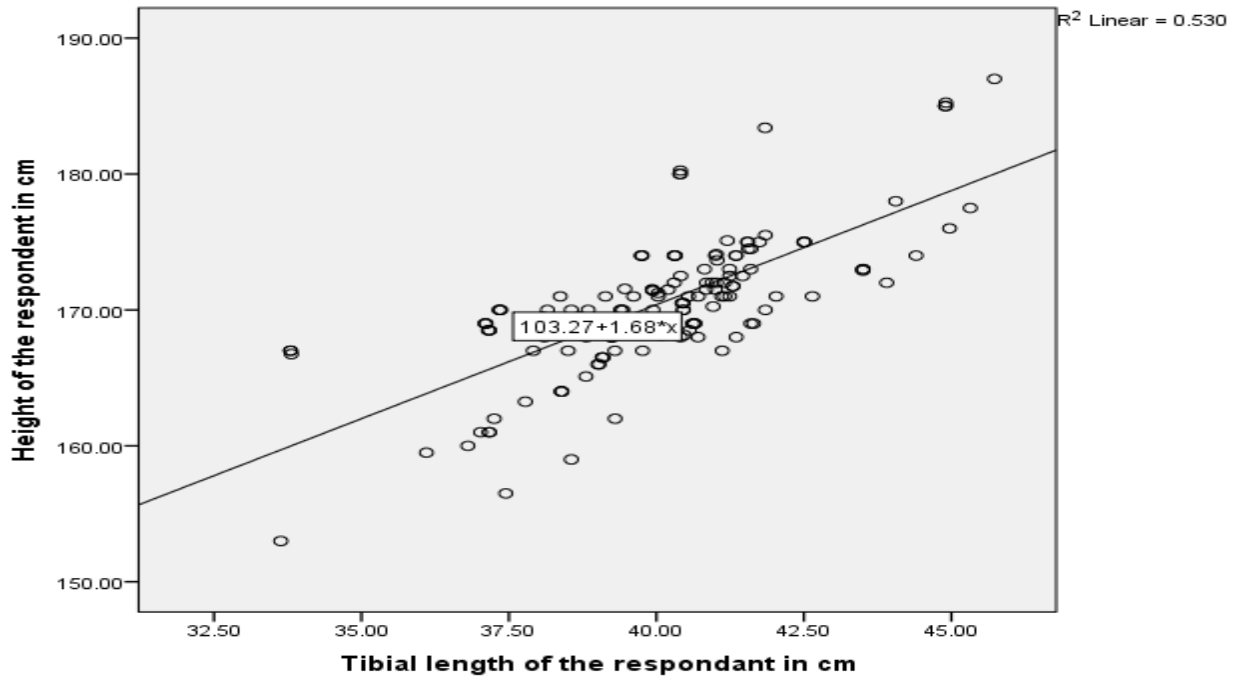


Figure 7:Regression line between height and tibial length of male participants in Addis Ababa

The regression line for tibial length with height was drawn from data analysis of male participant. This scatter plot illustrates that there is linear relationship between tibial length and stature of participants. And stature of participant increases with increase in tibial length and vice versa.

5.4.2 Simple linear regression equations to estimate of stature from anatomical anthropometric parameters for female participants.

Simple Linear regression equations were formulated for each anatomical anthropometric measurement to estimate stature for female participants. Estimation of statures from each anatomical anthropometric measurement of female participants is provided in table 10. The R value was largest in foot length and smallest in bimalleolar width. Whereas the smallest SEE value was observed in foot length and largest value was in bimalleolar width (Table 10). Simple regression model to estimate stature for female participants using foot length was height = $71.02 + 3.82(\text{foot length})$ with $R=0.744$ and the regression model to estimate height from bimalleolar width was height = $119.047 + 6.40(\text{bimalleolar width})$ with $R=0.488$. All the

anthropometric parameters significantly estimated the standing height of participants with significance of $P < 0.000$.

Table 10: Estimation of stature from anatomical anthropometric parameters of female participants in Addis Ababa, Ethiopia 2023

Parameters	R	R ²	SEE	Regression equation	Sig.
Tibial length(cm)	0.624	0.390	4.554	$93.89 + 1.76(TL)$	.000
Bimalleolar width(cm)	0.488	0.238	5.089	$119.05 + 6.40(BMW)$	.000
Foot length(cm)	0.744	0.553	3.899	$71.02 + 3.82(FL)$	.000

TL-tibial, BMW- Bimalleolar width, FL-foot length R-correlation coefficient, R²-coefficient of determination and SEE- standard error of estimate

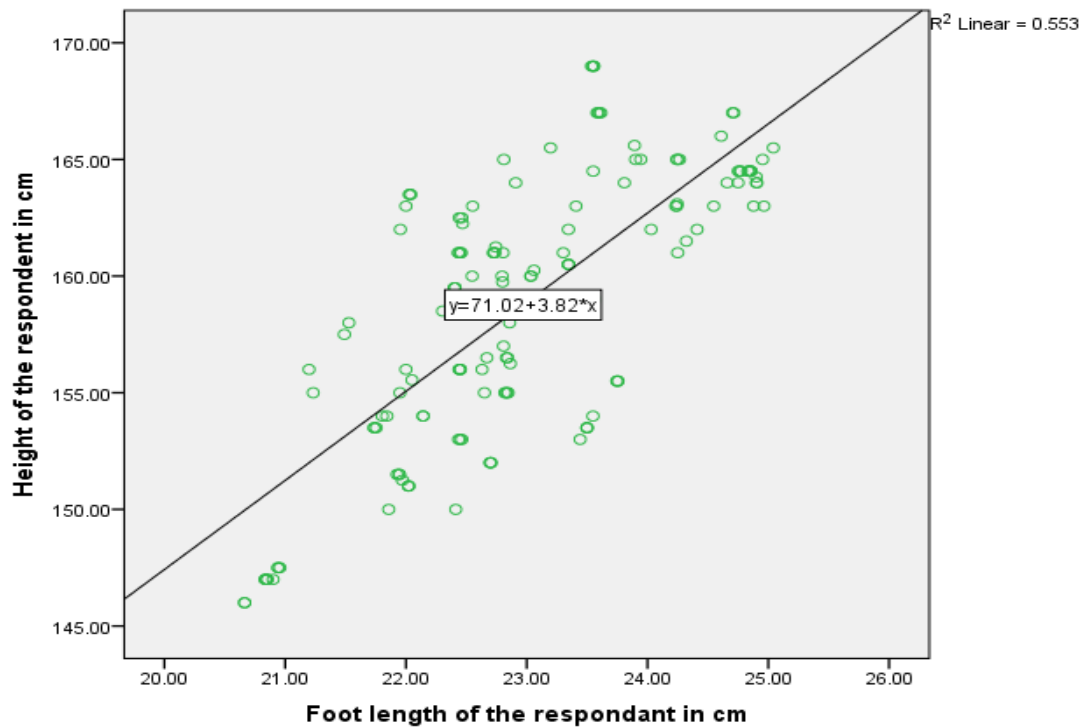


Figure 8: Regression line between height and foot length of female participants in Addis Ababa, 2023

The regression line and coefficient of determination for foot length with height was drawn from data analysis of female participants. This scatter plot illustrates that there is linear relationship between foot length and standing height of female participants. And stature of participants increases with increase in foot length and vice versa.

5.4.3 Simple linear regression equations to estimate of stature from anatomical anthropometric parameters for combined sex participants.

Simple linear regression equations were formulated for each anatomical anthropometric measurement to estimate stature for combined sex participants. Estimation of statures from each anatomical anthropometric measurement of combined sex participants is provided in table 11. The R value was largest in foot length and smallest in bimalleolar width. Whereas the smallest SEE value was observed in foot length and largest value was in bimalleolar width (Table 11). Simple regression model to estimate stature for female participants using foot length was height = $57.96 + 4.46(\text{foot length})$ with $R=0.813$ and the regression model to estimate height from bimalleolar width was height = $98.056 + 10.18(\text{bimalleolar width})$ with $R=0.703$. All the anthropometric parameters significantly estimated the standing height of adolescents with significance of $P<0.000$.

Table 11: Estimation of stature from anatomical anthropometric parameters for combined sex participants in Addis Ababa, Ethiopia 2023

Parameters	R	R ²	SEE	Regression equation	Sig.
Tibial length(cm)	0.803	0.645	4.750	$71.18 + 2.43(\text{TL})$	.000
Bimalleolar width(cm)	0.703	0.494	5.677	$98.06 + 10.18(\text{BMW})$	.000
Foot length(cm)	0.813	0.662	4.641	$57.96 + 4.46(\text{FL})$	.000

TL-tibial, BMW- Bimalleolar width, FL-foot length R-correlation coefficient, R²-coefficient of determination and SEE- standard error of estimate

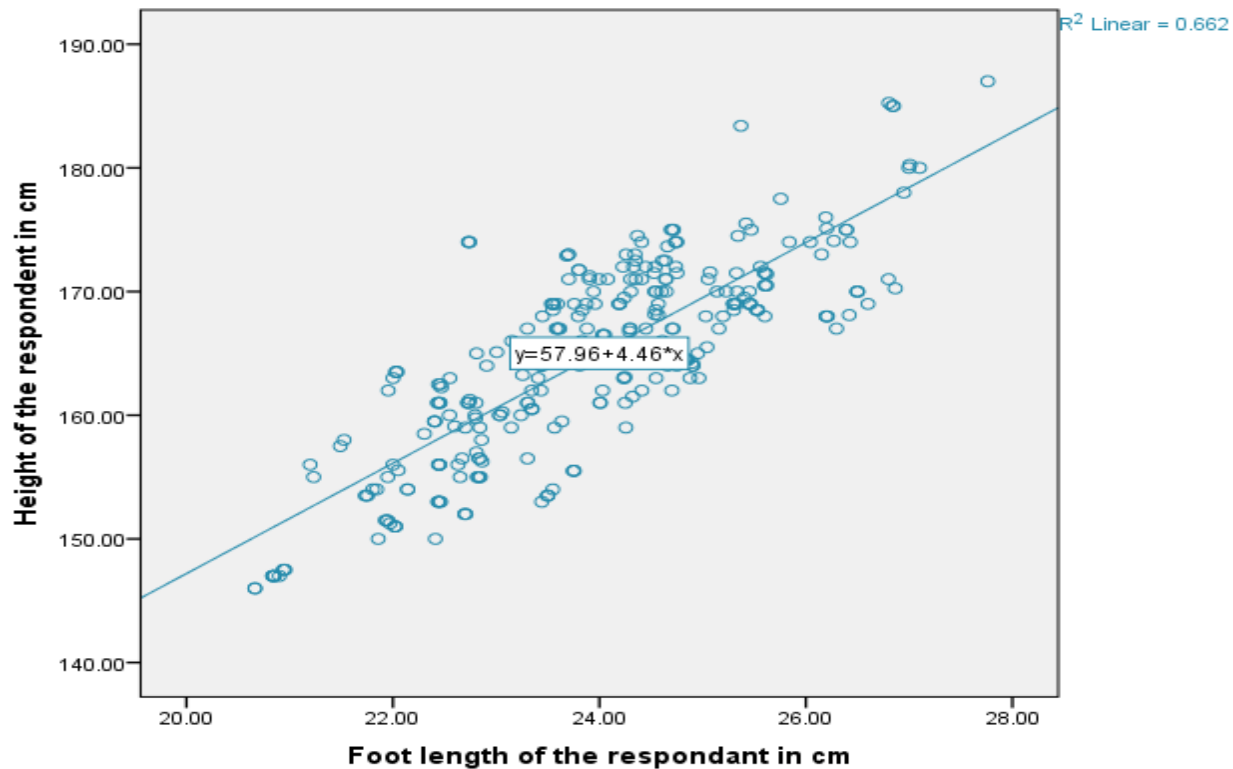


Figure 9: Regression line between height and foot length of combined sex participants in Addis Ababa, Ethiopia, 2023

The regression line and coefficient of determination for foot length with height was drawn from data analysis of combined sex participants. This scatter plot illustrates that there is linear relationship between foot length and standing height of participants. And stature of participants increases with increase in foot length and vice versa.

6. Discussion

Stature is usually estimated by two well-known methods. The Fully's method was one of the earliest methods. In this method, measurements were taken from all skeletal portions that contributed to the height of a person with some adjustments made for soft tissue between the vertebral joints that are usually present in life (10). In this study, stature was estimated by using several parameters of lower limbs to produce population-specific formula for the specific population. This study may be useful to the law enforcement agencies and forensic scientists to identify incomplete skeletal remains. In real life, it is not uncommon to find skeletons in adverse conditions, particularly in mass disasters (11,12) Many bodies are crushed or merely destroyed or maybe taken away by animal scavengers (11,12) In such cases, it may be impossible even to apply the Fully's method, which needed all skeletal portions to estimate stature. Hence, it would be practical to use the mathematical method for stature estimation (10).

The long lower limb bones were mostly used as they are more robust, and are thus, likely to be available in forensic scenarios Hence, lower limbs were chosen in this particular study for estimation of stature (11,12)

The present study was designed to estimate stature from anatomical anthropometric measurements including tibial length, Bimalleolar width and foot length among 300 participants (150 in each sex) in Addis Ababa. The age range of the students was between 18 to 25 years.

The results of this study are in line with the study conducted on a high school based cross-sectional study that was carried out among 416 High school students in age range of 15-18 years in Addis Ababa, Ethiopia, the results of both studies showed that the mean height and other anthropometrics measurements in male participants was significantly higher than the female study participants (13). and the results of many other studies conducted across the globe also indicated higher mean stature and other anthropometric parameters of male participants were also shown ((15)(17),(18).

In the current study tibial length was found to be significantly correlated with standing height in both males and females ($P < 0.05$). The correlation coefficient (R) between height and tibial length in males was $R = 0.728$ and the correlation coefficient (R) between height and tibial length in females was $R = 0.624$. Tibial length was also found to be strong predictor of height in study

carried out among 416(202 males and 214 females) high school students in Addis Ababa from May to June 2019 and Six anthropometric measurement including tibial length was measured and the correlation coefficients (R) of anatomical anthropometric measurements with height were: right tibial length (males R= 0.738, females R= 0.611), and left tibial length (males R= 0.744, females R= 0.599). stature predicted from all anthropometric measurements were valid indicator of height(13).

Similarly, study done on 600 people in the age range of 21 to 45 in the Nigerian state of Cross River, peri-cutaneous tibial length was used to determine height. The findings showed, the correlation coefficients (R) of tibial length with height was 0.565 for males and 0.507 for females which was also found strong predictor of height(15)

Similarly, institutional-based, cross-sectional, prospective study was conducted among 572 first year undergraduate students at Deber Markos university from April to June 2018 in both sexes and the outcome revealed strong correlation with correlation coefficients (R) of tibial length with height were right tibial length (males R = 0.634, females R = 0.259), left tibial length (males R = 0.632, females R = 0.258) however, in this study, the degree of correlation for females found to be low degree of correlation(R) of 0.259 and 0.258.for right and left respectively.

In another investigation directed on a sum of 240 kids (116 young men and 124 young ladies) of age 3-11 years and having a place with Bengali Hindu standing, stature was seen as significantly connected with tibial length with Pearson correlation coefficient of 0.856 and p-value of <0.01 among young boys and tibial length with Pearson correlation coefficient of 0.937 and p-value of <0.01 among young girls.

The correlation coefficient in the present study was also similar with another study of 100 right-handed Saudi men (aged 18-24 years) it was reported the correlation coefficient (R) between height and tibial lengths in males was 0.825 (27).

In this study, foot length was significantly correlated with height in both males and females ($p < 0.05$). The correlation coefficient (R) of height with foot length was R = 0.553 and R = 0.744 in males and females respectively. Similarly, this finding is corroborated by research that was done on an institutional-based, cross-sectional, prospective study involving 572 first-year undergraduate students at Deber Markos University in both sexes between April and June 2018. The results revealed a strong correlation for males' participant with correlation coefficient of R =

0.579 and $R = 0.581$ for the right and left foot length respectively. however, on the contrary to my study, it revealed that the degree of correlation for females found to be very weak degree of correlation(R) of 0.185 and 0.186 for right and left respectively(14)

This finding is supported by a study conducted in Nepal aimed to estimate the stature of indigenous population using foot measurements amongst adult Nepalese, the researchers collected 440 different foot length and body height measurements and height from students of age group 17 to 25 years, and the result showed the correlation coefficient between height and foot length is + 0.688 in male and + 0.587 in female which is highly significant(19).

A study by Altayeb Abdalla Ahmed (2020) in 100 right- handed Saudi Arabian men aged 18-24 years and six lower limb dimensions were measured bilaterally. And The researchers concluded that regression formulae developed from foot length measurements showing significant correlations method for estimating the height next to the tibial length and the correlation coefficient for foot lengths were ($r = 0.712$ and 0.700 for the right and left feet, respectively)(21).

In the present study, was significantly correlated with height in both males and females ($p < 0.05$). The correlation coefficient (R) of height with bimalleolar width was $R = 0.460$ and $R = 0.488$ in males and females respectively. Bimalleolar width was also found to be good predictor of height. Similarly, study conducted by Altayeb Abdalla Ahmed in a sample of 160 (80 men and 80 women) Sudanese Arban aged 25-30 years old individuals and the researchers concluded by depicting the lower degree of correlation coefficients were observed with correlation coefficient for males ($r = 0.349$) and for females ($r = 0.367$)(8).

On contrary, a study conducted on sex and stature prediction among adult Lagmos dwellers using foot anthropometry and done by Nwachukwu Mike Ibeabuchi and his other 4 colleagues on a sample of 222 in Nigerian aged between 18-65 years and found that bimalleolar breadth was a not significant predictor of stature and correlation coefficients (R) of bimalleolar width with height were right bimalleolar width (males $R = 0.269$, females $R = 0.225$), left bimalleolar width (males $R = 0.144$, females $R = 0.161$) however, in this study, only the degree of correlation for right bimalleolar width in case of male, found to demonstrate moderate correlation whereas the reset finding found to be weak correlation(R) (22).

Additionally, the current study also formulated simple linear formulas from tibial length, bimalleolar width and foot length separately for each and for combined sexes. The accuracy of

simple linear regression equations was assessed by using coefficient of determination (R^2) and standard error of estimate for each of anatomical anthropometric parameter. Result of the present study in table 9 indicated that R^2 value in male participants were 0.212 for bimalleolar width, 0.306 for foot length and 0.530 for tibial length and standard error of estimate were 3.437 for tibial length, 4.176 for foot length and 4.452 for bimalleolar width respectively. Regression equation with the highest value of R^2 and lowest value of SEE is relatively best estimator as compare with models with lowest R^2 and higher SEE as a result of this, the equation formulated by tibial length for males had highest R^2 and lowest SEE as compared with other anthropometric parameters and R^2 was the smallest and the standard error of estimate (SEE) value was largest in bimalleolar width as result of this the equation formulated by using bimalleolar width is not a good estimator as compare to the tibial length. According to table 10 indicating the highest R^2 value in female participants was 0.553 for foot length and lowest R^2 was 0.238 for the bimalleolar and regarding the highest standard error of estimate was 5.089 for bimalleolar width and the lowest was 3.899 for foot length. So, this indicated that the equation formulated by foot length for females had highest R^2 and lowest SEE as compared with other anthropometric parameters and similarly table 11 depicting the similar result for the combined sexes as well.

Similarly, the result of the present study was in agreement with numerous studies like Study done in Deber Markos university which depicted that tibial length (highest R^2 and lowest SEE for both participants. On contrary to this, my study showing highest R^2 and lowest SEE in foot length anthropometry in cases of female participants highest R^2 and lowest SEE. Likewise, A study by Altayeb Abdalla Ahmed (2020) in 100 right- handed Saudi Arabian men aged 18-24 years and six lower limb dimensions which inferred that highest R^2 and lowest SEE for tibial length as compare to other anthropometric parameters (21). However, the A high school based cross-sectional study that was carried out among 416 High school students in Addis Ababa from May to June 2019, showed the highest R^2 and lowest SEE in cases of arm length as compared with other anthropometric parameters including the tibial length(28).

The differences among studies may be due to differences in measuring instruments and measuring error, or be due to genetic and environmental factors, such as nutrition and climate, in the two study populations.

7. Conclusion

Stature has showed statistically significant correlation with tibial length, Bimalleolar width and foot length in both sexes.

Tibial length highly correlates with height and regression equations fitted from tibial length was found to be best estimator of height among age 18-25 in both sexes.

Over all mean value of stature, Tibial length, Bimalleolar width and foot length were significantly higher in male adolescents than their female counter parts.

There is statistically insignificant difference between handedness and anthropometrics measurements in both male and female study participants.

Simple linear were formulated from each anatomical anthropometric parameter to predict stature of an individual.

Generally, tibial length, bimalleolar width and foot length can be used as a good predictor of stature when difficulty arose in linear measurement of height, in case of mass disasters and for forensic investigations purposes.

8. Limitation of the study

It is difficult to compare the results of the current study with those of national investigators due to the lack of complete literature on the estimation of stature from tibial length, bimalleolar width, and foot length among 18 to 25 years of age.

some students' refusal to take part in the study because they found taking measures to be physically uncomfortable.

9. Recommendation

Similar studies with participants ages of 18 to 25 years should be carried out, as these individuals can be used to represent a range of age groups and geographic locations. nationwide guideline should be developed to estimate stature tibial length, bimalleolar width and foot length.

It is recommended to conduct on further detailed studies on other body parameters (especially from femur length) to estimate stature on 18 to 25 years of age.

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ANNEXES

Annex 1: Informed Consent Form (English version)

St Paul Hospital millennium medical college

Subject Information Sheet

Hello, my name is Dr Eyob Tsegaye, Student at the Department of Forensic medicine and toxicology in SPHMMC. I am conducting research on “Estimation of Stature from Lower Limb Anthropometry amongst 18-25 years in SPHMMC, Addis Ababa, Ethiopia.” I have received permission from SPHMMC to conduct this study.

You are selected by Simple random sampling method to participate in this study because you are currently attending in the SPHMMC medical school for the study purpose. Your participation in this study is totally based on your willingness. You have the right to choose not to take part in this study. If you choose to take part, you have also the right to stop or withdraw at any time of the study.

If you agree to participate in this study, your height, femur length, tibial length, bimalleolar width and foot length will be measured. You will also be interviewed about background information. You can stop at any time if you don't feel comfortable during an interview and measurement process. The measurement and filling the questionnaire will take about 10 minutes.

Informed Consent and/or Ascent Form

Based on the understanding of the above information, are you willing to participate in this study?

A) Yes

B) No

If yes, I will continue and

If no, I will skip to next participant

Annex 2: በመረጃ የተደገፈ የስምምነት ቅጽ (Amharic Version)

የቅዱስ ጳውሎስ ሆስፒታል ሚሊኒየም ሜዲካል ኮሌጅ

ጤና ይስጥልኝ ስሜ ዶ/ር እዮብ ፀጋዬ እባላለሁ በቅዱስ ጳውሎስ ሆስፒታል ሚሊኒየም ሜዲካል ኮሌጅ የፎረንሲክ ሜዲሰን እና ቶክሲኮሎጂ ትምህርት ክፍል የመጨረሻ አመት ተማሪ ነኝ።

ዛሬ እዚህ የመጣሁት ከታፋ ርዝመት፣ የጭኑ ርዝመት፣ የቢሚኤላር ስፋት እና የእግር ርዝመት

ያለውን የቁመት ግምት መረጃ ለመስብሰብ ነው። በዚህ ጥናት ላይ ለመሳተፍ ለጥቂት ደቂቃዎች ጊዜዎን እጠይቃለሁ። በዚህ ጥናት ውስጥ በጣም ጠቃሚ ይሆናል እናም በሚስጥር ይጠበቃል። የተሳታፊው ስም እና አድራሻ አይመዘገብም። በዚህ ጥናት ውስጥ ያለዎት ተሳትፎ ሙሉ በሙሉ በፈቃደኝነት ነው። መሳተፍ ወይም አለመሳተፍ የእርስዎ ምርጫ የተጠበቀ ነው። በዚህ ጥናት ውስጥ ለመሳተፍ ከተስማሙ ቁመትዎ፣ የእግር ታፋ ርዝመት፣ የጭኑ ርዝመት፣ ቢሚኤላር ስፋት እና የእግር ርዝመት ይለካሉ። ስለ ዳራ መረጃዎ ቃለ መጠይቅ ይደረግልኛል። በቃለ መጠይቅ እና በመለኪያ ሂደት ውስጥ ምቹነት የማይሰማዎት ከሆነ በማንኛውም ጊዜ ማቆም ይችላሉ። መለኪያው እና መጠይቁን መሙላት 10 ደቂቃ ያህል ይወስዳል።

Thank you for your kind cooperation

Data collector

Name _____ Signature _____

Questionnaires ID number _____

Date of data collected _____

Result of data collected

A) Completed

B) Not completed

C) Partially completed

D) Refused

Checked by Supervisor: Name _____ Signature _____

For further explanation, use the Principal Investigator's Address;

Name: Eyob Tsegaye

Email: eyobt8443@gmail.com

Cell phone: +251 920109116

Annex 3: Data collection tool

Table 5: Part I. Socio-demographic Variables

SN	Questions	Alternative response
1.1	Sex	1. Male 2. Female
1.2	Age in full years	_____years
1.3	Handedness	1. Right handedness 2. Left handedness
1.4	Do you have long bones skeletal and spinal deformities and lower limb bone and spinal bone fractures?	Yes_____ No_____ Specify_____

Table 6: Part II. Anthropometric indices check list

No	Anthropometric indices	Equipment	Result	Average result
2.1	Height(cm)	Stadiometer	1 st measurement	
			2 nd measurement	
2.3	Tibial length(cm)	Vernier caliper	1 st measurement	
			2 nd measurement	
2.4	Bimalleolar width(cm)	Vernier caliper	1 st measurement	
			2 nd measurement	
2.5	Foot length(cm)	Vernier caliper	1 st measurement	
			2 nd measurement	

Data Collector name; -----Sign; ----- Date; -----

Assurance of the Principal Investigator

I, the undersigned, agree to accept all responsibilities for the scientific and ethical conduct of the research project and for the provision of required progress reports as per the terms and conditions of the requirements of the department. I will provide timely progress report to my advisors and seek the necessary advice and approval from my advisor in the course of the research.

Name of Investigator: Dr. Eyob Tsegaye (Year III FMT Resident)

Signature: _____

Date: _____

S.t Paul's Hospital Millennium Medical College

Department of Forensic Medicine and Toxicology

Advisor's Approval Sheet

This is to certify that the research proposal entitled “**Estimation of Stature from Lower Limb Anthropometry Measurements among 18-25 years in Addis Ababa, Ethiopia.**” is submitted in partial fulfillment of the requirements for the specialization Certificate in FMT to the Graduate Program of the Saint Paul Hospital Millennium Medical College and will be conducted by Dr. Eyob Tsegaye (Year III FMT resident) under our supervision. Therefore, we recommend that the student can submit the research proposal.

Name of Advisors

- 1. Dr. Alula Shibabaw (MD, Assistant Professor of FMT)**

Signature;

Date;