ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES AND MEDICINE

SCHOOL OF GRADUATE STUDIES DEPARTMENT OF ANATOMY

ESTIMATION OF STATURE FROM HAND LENGTH AND HAND BREADTH ON MEDICAL STUDENTS AT ADDIS ABABA UNIVERSITY AND ST.PAUL HOSPITAL MILLENNIUM MEDICAL COLLEGE, ADDIS ABABA,ETHIOPIA

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List of Abbreviation

BH	Body Height
BMI	Body Mass Index
cm	centimeter
HB	Hand Breadth
HL	Hand Length
Kg	Kilogram
LHL	Left Hand Length
LHB	Left Hand Breadth
m	meter
MD	Mean Difference
mm	Millimeter
RHL	Right Hand Length
RHB	Right Hand Breadth
S	Stature
SEE	Standard Error of Estimate
SEED	Standard Error Difference
SD	Standard Deviation
SPSS	Statistical Package for Social Science
WHO	World Health Organization

ABSTRACT

Introduction: Stature of an individual is an inherent character and considered as one of important parameter of personal identification and to assess nutritional status; it is the sum total of different axial and appendicular bones. Each components of bone has its own relation to stature; and stature can be estimated both anatomically and mathematically. In most cases getting complete bone and measuring stature directly is difficult due to these challenge; estimation of stature from different parts of body is focus of many researchers.

Objective: To assess correlation between hand length, hand breadth and stature of medical students and create regression equation to estimate stature.

Methods and Materials: Cross-sectional descriptive study was conducted on 210 first year medical students at Addis Ababa University and St. Paul Hospital Millennium Medical College from January to August 2017. Participants were selected by simple random sampling method. Stature, hand length, hand breadth and weight of students were measured and a pretested questionnaire prepared in Amharic and English was used to gather sociodemographic data. Data was processed by using SPSS software version 23 for calculation of Mean, SD, correlation coefficient, regression coefficient and the value of constant to estimate stature. P-value less than 0.05 was taken as statistically significant.

Results: About 51.4 % of participants were male and the mean age of participants was 19.45± 0.993 SD. The mean value of stature was172.715±5.218SD cm and 160.166±6.078 SD on male and female participants respectively. Hand length and hand breadth shows statistically significant correlation (r 0.229 - 0.720, $p<0.05$) with stature. All Morphometric measurements show statistically significant ($p<0.05$) sexual dimorphism. Only hand breadth exhibit statistically significant bilateral asymmetry. Regression equation derived from hand length shows larger R^2 value than hand breadth in both participants. The SEE of estimate was higher in hand breadth than hand length in both sexes. The result indicated that there was no statistically significant mean difference ($p>0.05$) between estimated and actual stature for both sexes.

Conclusion: Hand length and hand breadth have statistically significant relation with stature; thereby stature could be predicted by both hand breadth and hand length when difficult conditions occurred.

Keywords: Stature, Hand Length, Hand Breadth, Estimation

1. INTRODUCTION

1.1 Back ground

Stature(S) is natural height of a person in an upright position and its maximum size is gained at adolescent stage of development. Body height (BH) is anatomically complex that includes the dimensions of legs, pelvis, vertebral column and skull. The contribution of each bone to total stature varies from population to population (1).

Dimensional relationship between the body segment and the whole body is the focus of scientists, anthropologists and anatomists for many years. Furthermore, the relation between body segment and whole body height is used to compare variations between different ethnic groups and to relate them with locomotion pattern, energy expenditure and life style (2).

Proportions and dimensions of various body segments such as long bone of limb, foot and hand are used to estimate body stature. Prediction of stature from body segment is important in many areas of modern science. For instance, in growth and development to assess normal growth as well as specific syndromes, but the height of an individual cannot be estimated directly, from bedridden, who have limb and vertebral column deformity, emergency and critically ill patients; of these situations occurred, visual estimation is one of the most common method to guess the patient height but it is not reliable and scientific (3). Scientific indirect estimation can be achieved by correlating the height with other skeletal parameters (4).

On the other way identification of a human body from decomposed or mutilated due to natural disasters and traffic accident is an essential for all medico-legal scenarios and humanitarian grounds; relationship between body dimension and stature can be used to solve crimes in absence of complete body portion by providing biological profile (5). Anthropologists and forensic experts have given more importance to the various methods of stature estimation.

A number of methods have developed in the last few centuries for stature estimation. One particularly time consuming method involves taking the sum of the heights of all skeletal elements; This method is rarely used, due to the number of hours required, and it is relatively rare to recover a complete human skeleton in forensic cases. Other method uses only the measurement of one or two long bones, rather than the sum of all skeletal elements and the derive regression equations to estimate stature (6).

In the first study, Rollet assessed the correlation between stature and long bone length; he measured the lengths of the radius, ulna, humerus, fibula, tibia and femur of adult French cadavers and published a report with the methods of measurement, and tables of stature estimations (8).

Adam and Herrmann found that stature estimation derived from anthropometric measurements provide comparable result with skeletal standards without need for dissection ;in mass death scenarios maceration of body part to get skeleton is time consuming as result measurement of fleshed body part afford practical and accurate alternative method for biologically profiling victims(9).

Pearson used Rollet's data to create regression formulae for estimating stature. Trotter and Gleser found that stature declines with age. They speculated that thirty years was approximately the age where stature begins to decrease at a rate of 0.06 cm per year (8,10) .Trotter and Gleser also compared the average stature of the cadavers from Washington University to that of a sample of the living population and found that the average cadaver was approximately 2.5 centimeters taller than the average sampled living stature (8).The equations provided by FORDISC, based on the Forensic Data Bank and the Trotter and Gleser formulae, are the most commonly used in forensic anthropology today, though they are not applicable to all population (11).

Estimation of stature by percutaneous body measurements has been carried out in several studies and researchers develop their own formula from different parts of the body to estimate stature (12). Estimation of stature from hand length and breadth is important not only for forensic science but also for other study disciplines such as anatomy, medicine and anthropology (13).

1.2. Statement of problem

Estimation of stature play important role for determination of basic energy requirement, for measuring physical capacity, assessment of growth and nutritional status, adjusting drug dosages, determine pulmonary function and body mass index, renal clearance and other patient care issues(2). Even if measuring stature is such vital, there are conditions that we cannot measure stature directly from patients that cannot stand due to neuromuscular weakness, deformities of axial skeleton such as kyphosis, scoliosis, lordosis, contracture, osteoporosis, and spasticity. Forexample, in scoliosis patients, the predicted spirometric values were underestimated when the measured body was used and in such situation estimating stature from other part of the body is alternative way to cope up with this problem (14).On other hand, establishing the identity of an individual from mutilated, decomposed, and amputated body fragments has become an important necessity in recent times due to natural disasters like earthquakes, tsunamis, cyclones, floods and man-made disasters as in terror attacks, bomb blasts, mass accidents, building collapse, car accident, wars, and plane crashes which cause mass fatalities. WHO report indicates more than 1.2 million people die with only traffic accident every year and 90% of death is from low and middle income countries (15).According to WHO annual natural disaster statistical review of 2015, in average about 380 natural disasters occurred annually and cause death of 199.2 million people till 2005 to 2014 worldwide. When such disasters occurred victims may present in the form of fragmented, scattered ,and mixed together this cause difficulty to build complete biological profile, so estimation of stature from different body part play vital role in forensic anthropological field to fill the gap of biological profile for identification of person after death(16) and there is no any study in Ethiopia to predict stature from hand length ; due to this reason the current study aims to estimate stature from hand length and hand breadth of medical students at Addis Ababa university and St. Paul Medical College.

1.3. Significance of study

Stature provides insight into various features of a population including nutritional health and genetics. Stature estimation is utilized in a similar fashion as with crime scene investigation and to narrow down the possible identities of victims. Stature is considered as one parameter for personal identification. Knowing correlation between hand length, hand breadth and stature is very crucial for forensic anthropologist to complete biological profile, anatomists, medical researchers, policy makers, planners and other collaborators to design a series of interventions. Therefore, this study can serve as an input for policy makers and planners. Even if there is plenty of study done in America, Europe, Asia and Africa; there is no study conducted on estimation of stature from hand length and breadth in Ethiopia, hence, there is a need to carry out a research to fill this gap. Furthermore, this study can be used as a base line data for further studies.

2. LITERATURE REVIEW

Establishment of identity of unknown human remains is a challenging task in medico-legal cases, especially when the remains are partial, mutilated or dismembered. Such situations usually arise in cases of natural disasters, rail and aircraft accidents, wars and terrorist explosions. Many times, only parts of human body, such as limbs, are available for identification (13, 15) Parameters used by several authors for identification purpose include hand length, hand breadth, foot length, foot breadth and their indices (17).

Even though the Trotter and Gleser equations have been the most widely utilized stature estimation equations used in forensic anthropology since 1952, it is doubtful that these equations remain relevant to modern population.

2.1 Approaches for estimation of stature

Estimating stature from unknown skeletal remains is one of the essential biological parameters in the development of biological profile. Currently there are two approaches to estimate stature; mathematical and anatomical methods. Mathematical method requires the measurement of intact single or multiple skeletal elements, and the use of population, sex, tempo-specific regression equations (18). Incomplete long bones can also be used to estimate stature when complete long bones are not available. These methods are useful for estimating stature in forensic and archeological contexts where the remains are damaged or incomplete as a result of human and other taphonomic processes (19).

The anatomical method (also referred to as complete skeleton method) requires the measurement of all bones that contribute to stature, namely the heights of cranium, second cervical to fifth lumbar vertebra, first sacral body physiological length of femur, and the maximum length of tibia, and articulated talus and calcaneus. Subsequently, the measurements are summed, and a correction factor is applied to obtain a stature estimate.

Both mathematical and anatomical methods are enhanced by additional correction for age due to age-related stature loss (20).

2.2. Difference between Living stature and cadaver stature

Manouvrier first noted a discrepancy between living stature and cadaver stature; andrecommended2.0 cm to be subtracted from cadaver stature to obtain an individual's living stature. He postulated that this difference was due to the compression of soft tissues when a living person stands erect (21).

Trotter and Gleser (1952) noted an average decrease of 2.5 cm between cadaver and living statures. Conversely, some researchers did not agree with presence of noticeable difference between living stature and cadaver stature. Among suggested increments for the conversion of cadaver stature to living stature (and vice versa), Trotter and Gleser's recommendation of 2.5 cm has been most often utilized by researchers now a days(8). The difference in statures is due to an expansion of intervertebral soft tissue, loss of water and muscle tonicity in cadavers, and according to Trotter and Gleser, it can be assumed that the living stature and cadaver stature differences are constant so can be applied to different ancestral groups and sexes as a 'blanket' adjustment.

When comparing standing height and supine height, intervertebral discs are subject to time dependent deformities when exposed to loading therefore cause modification in body height (8). Further, as stated by Krishan et al. (2010), the force of gravity when standing and walking causes compression of the intervertebral discs, with the vertebral column influencing changes in height more than any other joint in the body (22). A study by Gray et al. (1985) showed a difference of 3.68cm between standing height and supine height measured while the patient is in bed and suggested that compressibility of the axial skeleton may contribute to the difference (23), generally a number of factors that need to be taken into consideration when measuring an individual's stature from human remains.

2.3. Factors affecting human stature

2.3.1. Environment

It is clear that interaction of genes and environment are largely responsible for the apparent diversity in modern human population; this continuous interaction influences the final size and shape that a child achieves as an adult. Physical environment is known to be a major influence of long ranged adaptation differences in human body size and proportions (25).Population variation due to environment is the primary reason why one stature estimation equation cannot be applied to a variety of populations since environment affects growth. People, particularly of lower socioeconomic status, that live at high altitudes, or have experienced poor nutrition and health, tend to not reach their true genetic potential (24). However, if these people place themselves in a healthier environment, they can reach their genetic height, as can their children. Various parts of the body may respond differentially to changes in the environment or develop at different rates. Both environment and genetics play a role at different stages of a child's development, and vary between even two closely related populations (25,31).

2.3.2. Nutrition

Studies of living populations have shown that growth in childhood is strongly correlated with nutrition. If nutritional stress is not overly severe, it may simply slow physical development and increases the individual's susceptibility to infectious disease; however, if it is severe, it can result in death (25).Malnutrition results in failure to grow, involving both weight and height. Skeletal development is essential for the growth process, and the different hormones involved in growth each have their own regulatory effect on skeletal formation .Malnutrition causes retardation of skeletal formation. When there are periods of arrested growth caused by either disease or malnutrition (26).

2.3.3. Altitude

Individuals indigenous to high altitude have been demonstrated having enlarged chest and lung compare to people residing to lower altitude. These adaptations arise because of the air is thinner at higher altitude, which can lead hypoxia. Hypoxia occurs when the oxygen in the air at high altitudes is less concentrated and, consequently, is at a lower pressure than it is at low altitudes .The effects of hypoxia include increased heart rate, shortness of breath, physical fatigue and digestive disorders (26). For example, at 4,500 meters the partial pressure of oxygen is decreased up to 40 percent .Growth retardation is proportional to the degree of hypoxia, and hypoxia exists along an altitude gradient (28).

2.3.4. Climatic condition

In warm and hot climate adaptation to maximize heat loss is important for survival. Heat production is proportionate to body mass and heat loss is proportionate with body surface area. According to Allen rule endothermic mammals found in colder climate usually have shorter limb than equivalent animals found in warmer climate. This theory suggests that people who reside in warm environment have relatively longer limb and narrower body than those from cold environment (25).

2.3.5. Genetics

It is well known that human growth is polygenic process; final adult size and shape controlled with interaction of numerous genes. It has been suggested that between 70 to 90 % of adult height is genetically determined. The study of height has a long standing tradition in genetics; in fact, the field of quantitative genetics was born out of studies of human height in the late 19^{th} and early 20^{th} centuries. Galton published data as early as 1886 on the relationship between parent and offspring height (29). Later on, Pearson and Lee presented correlations of height between relatives, also providing evidence for the inheritance of height(30) additionally; In 1918 Fisher calculated the first heritability estimate of height; the proportion of total variation explained by genetic variation (31). Genetics appear to play an increasingly important role in explaining the variation in weight, height, and BMI from early childhood to late adolescence; genetics is more influential during late adolescence, whereas the environment has a greater effect on height during childhood (32).

2.3.6. Hormonal effect on stature

Growth with stature is under control of different hormones that affect longitudinal bone growth. Bone growth during childhood affected by growth hormone, insulin-like growth factor ,thyroid hormone ,triiodothyronine , thyroxine, and glucocorticoids; during puberty, the sex steroids such estrogen and androgen play the most significant effect in bone growth with width and length (35).

2.4. Sexual difference in stature

Females are shorter on average than males in every known population .This difference in stature between sexes is called sexual dimorphism of stature and exists in every society. Some populations have greater variation in mean heights between the sexes than do others; however, there has been no consensus as to why this occurs. Stature is genetically defined, as is sexual dimorphism in a population (33).

The origin of the height difference between males and females is most commonly hypothesized to result from hormonal, environment and sex chromosome composition. Sex steroids such as estradiol and testosterone are highly relevant for growth in closure of growth plates in the long bones and they also affect the secretion of other growth-related hormones such as growth hormone and insulin-like growth factor, therefore it is reasonable to hypothesize that the differential sex steroid patterns may produce at least some part of the sex difference in height (35). The influences of sex chromosomes are suggested by aneuploidies of the sex chromosomes such as Turner's, Klinefelter's and XYY syndromes but the mechanisms of action are not fully understood. Females with Turner's syndrome lack one copy of the X-chromosome (45, X0) and are characterized by short stature and ovarian failure, while males with Klinefelter's syndrome carry an extra copy (47, XXY) and manifest mild mental retardation and are slightly taller on average compared to males with the normal karyotype. The stature manifestations in these aneuploidies suggest that sex chromosomes may influence height via dosage effect of pseudoautosomal and Y-specific growth genes although the specific genes have yet to be identified (34).

2.5. The effect of aging on stature

It is generally accepted that stature declines with age. According to Giles and Hutchinson (1991) it is a reasonable assumption that populations, particularly those in the United States, will begin to decrease in stature starting in their mid- 40s. This minimal decrease begins for males at about 1 mm/year, and about 1.25 mm/year in females (35).

Stature estimation equations in use today require that adjustments be made to account for stature loss due to aging. Galloway (1988) found that height reduces on average by 0 .16 cm per year after age 45. She suggests that 0.16 centimeter times (age minus 45) should be incorporated in to stature estimation equation when analyzing older individuals above 45 years old(36). Trotter (1952) states that stature decreases from year thirty by 0.06 cm per year, and recommends the equation;0.06 times(age minus thirty) should be incorporated in to stature estimation equation when analyzing older individuals above 30 years old (8). It is known that the intervertebral discs tend to compress due to appearance of micro fractures, stiffen and become more fibrous with increasing age, causing the total vertebral length to decrease, resulting in an overall loss in stature (37).

2.6 Correlating hand length and breadth with stature

Hand is the manual part of the upper limb distal to the forearm. The wrist is located at the junction of the forearm and hand. Once positioned at the desired height and location relative to the body by movements at the shoulder and elbow. The skeleton of the hand consists of carpals in the wrist, metacarpals in the hand proper, and phalanges in the digits. When measuring the upper limb, or segments of it, for comparison with the contra lateral limb or with standards for normal limb growth or size, the acromial angle, lateral epicondyle of the humerus, styloid process of the radius, and tip of the third digit are most commonly used as measuring points, with the limb relaxed and with palms directed anteriorly (38);and hand breadth can be measured as maximum distance between 2^{nd}metacarpophalangeal joint and 5^{th}metacarpophalangeal joint(42).Study done on Bangladesh show statistically significant relation between hand breadth and stature with r-value of 0.17 and 0.19 for right and left hand breadth respectively (41).

Estimation of stature from extremities and their parts plays an important role in forensic medicine to identifying the dead in forensic examination. In forensic investigations, the dimensions of the hand and foot have been used in the determination of sex, age, stature of an individual (16,39).Different studies has been done to estimate stature using length of different long bones and length of hand, foot ,head and arm span(40,41).

Hand length and breadth have been shown to be a reliable and precise means in predicting the height of an individual and many researchers also found that hand length can be a good predictor of the body surface area independent of the sex of the Individual (42).

Studies conducted on Gujarati population suggest positive correlation coefficient and get 9.32,9.4 multiplication factor for male and female respectively and r=0.510 and 0.540 for right hand length of male and female respectively(43). Other studies done on medical students of Eastern India show multiplication factor (9.05,9.26) and $r^2=0.583(p<0.05)$,$r^2=0.487(p< 0.05)$ for hand length of male and female respectively(44).The study done on Kerala region reports the hand breadth ranges between 6.3 cm and 9.5 cm with r-value of 0.482 among study participants (15).

Hand Length (HL) and Hand Breadth (HB) have been extensively used in research to estimate stature of individuals for identification and have received scant attention from forensic anthropologists. This is due to the established strong correlation between stature and hand dimension. Ilayperuma Et al.,(2009) estimated personal stature of incomplete skeletal and decomposing human remains from hand length and showed 0.58 and 0.59 correlation coefficient for males and females respectively (45).Jasuja and Singh in their study demonstrate that hand length have a positive as well as statistically significant correlation with the stature (46).

Sangeeta and Kapoor performed stature estimation from the dimension recovered from hand outlines and it was revealed that Pearson's correlation was statistically significant between stature and hand dimension (42). Literatures suggest that it is possible to calculate stature through regression equation from hand length & Hand breadth (45).

3. OBJECTIVE OF THE STUDY

3.1. General objective

- To assess correlation between hand length, hand breadth and stature from medical students in Addis Ababa University and St. Paul Hospital Millennium Medical College.

3.2. Specific objectives

- To estimate stature from hand length and breadth.
- To establish linear regression formula for estimation of stature from hand length and breadth.
- To compare hand length and breadth, and stature between males and females.
- To establish multiplication factor to estimate stature from hand length and breadth.

4. METHODS AND MATERIALS

4.1. Study area

The study was conducted on first year medical students at Addis Ababa University, College of Health Science and St. Paul Hospital Millennium Medical College from July to August 2017 Addis Ababa, Ethiopia.

4.2. Study period

The study was conducted from July, 2017 –Aug 2017 two week data collection period.

4.3. Study design

Institutional based descriptive cross-sectional study was carried out among first year medical students at Addis Ababa University and St. Paul Hospital Millennium Medical College.

4.4. Source population

All fist year medical students at Addis Ababa University and St. Paul Hospital Millennium Medical College.

4.5. Study population

First year medical students at Addis Ababa University and St. Paul Hospital Millennium Medical College,who fulfill inclusion criteria.

4.6. Sample size

Sample size was determined statistically using the following formula

$N=Z^2S^2/d^2$, where

N=sample size

Z=critical value for z-score of 95% CI

S=expected standard deviation of events to be studied

d=margin of error

Since there is no study conducted in the study population, it will be with 95% confidence interval and 5% margin of error.

(Z=1.96, S=0.5, d=0.05) so by using above formula the minimum sample size required is 384 individuals. Since the above formula is used for total population of greater than 10000; and in this study the total population is less than 10000 correcting sample size formula was used as:

Corrected sample size= n×N⁄N+n,where

N=the size of source of population =466

n= size of non- corrected sample =384

So based on formula about 210 total sample size of population was included for the study.

4.7. Sampling method

The students who fulfill inclusion criteria were included by simple random sampling method. The number of students that should be included from both medical colleges was calculated according to their proportionality with total population. So by using the proportion formula about 131 and 79 students at Addis Ababa University College of Health Science and St. Paul Hospital Millennium Medical College were included in the study respectively.

4.8. Inclusion and exclusion criteria

Inclusion criteria

Students who are first year medical students and voluntary to participate in the study were included.

Exclusion criteria

- Students having any significant growth disorders of forearm and hand.
- Deformities of spine and extremities.
- Bony anomalies and fractures of forearm and hand.
- Students above 25 years old

4.9. Method of data collection

A pretested questionnaire was designed to collect socio demographic data such as age, sex, educational status of parents, Ethnic group, region and other related variables. Each volunteer participant was asked to fill the questioner and morphometric measurement was done by data collector. Standing stature was measured to the nearest 0.1centimeters (cm) using a Standiometer with subjects standing erect on a horizontal resting plane of Standiometer. The study participants were bare footed having the palms of the hands turn inward and the finger pointing downwards and the head, scapulae, back, and buttocks were positioned in contact with the vertical backboard. Each subject was then asked to maintain an upright position, with the head positioned in the Frankfort Horizontal Plane, as the horizontal sliding bar was lowered to the vertex of the head and stature was measured from the sole of the feet to the vertex of the head as recommended by International Biological Program then converted to the nearest 0.1cm as shown from figure1 (14).Weight was measured with standard mechanical balance by subjects standing on and the value was converted to the nearest 0.1Kg. The hand length was measured with digital sliding caliper in supine position when thumb was abducted but other fingers were adducted and extended by sliding digital caliper starting from midpoint of inter styloid line to the tip of the middle finger in extension (figure2)(42). Hand breadth was measured by sliding digital caliper as the maximum distance between the radial sides of 2ndmetacarpophalangeal joint to the ulnar side of 5thmetacarpophalangeal joint(figure3) (42).

Figure 1: Measurement of stature by Standiometer.

Figure 2: Measurement of Hand Length by digital caliper.

Figure3: Measurement of Hand Breadth by digital caliper

4.10. Study variables

Dependent variable

- ✓ Stature

Independent variable

- ✓ Age
- ✓ Sex
- ✓ Weight
- ✓ Hand length
- ✓ Hand breadth
- ✓ Ethnic group of student

4.11. Operational definition

Stature:-is biological height from sole of feet to vertex of head.

Hand length:-the length from mid styloid process to the tip of middle phalange.

Hand breadth:-maximum distance between the radial sides of 2^{nd}metacarpophalangeal joint to the ulnar side of 5^{th}metacarpophalangeal joint.

4.12. Data analysis and interpretation

Data was checked after and during collection from every participant for its completeness. Data was analyzed by using SSPS computer software version23.0 .Data was expressed as mean ± standard deviation (±SD). Pearson's correlation analysis was used to determine the strength of the relationship between the parameters studied. Bilateral asymmetry in the measurement data of each sex was evaluated using paired samples t-tests. Simple linear and multiple regression analyses were performed to derive regression equations for estimation of stature from hand measurements. The accuracy of stature estimation of each regression equation was assessed by the coefficient of determination (R2) and the standard error of the estimate (SEE). The significance level of the present study was set at p- value less than 0.05.

4.13. Data quality control

To maintain data quality, training was given for data collectors for two days and each metric measurement was measured three times and average was taken. The instrument and the procedure used were checked for every participant for its consistency.

4.14. Ethical consideration

Ethical clearance was obtained from research and publication committee of Addis Ababa University, College of Health Science, Department of Anatomy and IRB of St. Paul Hospital Millennium Medical College then official letter was received to start the study. The purposes and the importance of the study was explained to each study participant and no personal identifiers were used and verbal consent was obtained from each participant. Participants were informed that they have right to be excluded from study if they are not volunteer and all data kept confidential.

5. RESULTS

5.1. Sociodemographic characteristics of respondents.

A total of 210 students were included in the study. About 131(62.38%) from Addis Ababa University, College of Health Science and 79(37.6%) from St. Paul Hospital Millennium Medical College. From total sample 108(51.4%) of respondents were males and 102(48.6%) were females. The age of participants range between 18 and 22 years with a mean and standard deviation of 19.45±0.993.Majority 85 (39.5%), of participants were identified under Amhara ethnic group. Only 22(10.5%) of student's mother and 13(6.2%) of student's father were illiterate. Majority, 72(34.3%) of participant's family size was five. About 180(85.7%) of participants were from urban area and rest from rural area as shown in (table1).Study participants were coming from different region of the country following different religions. Majority of respondents 125(59.5%) were live in Subtropical climatic condition rest of them live in Cool, Tropical and Desert zones as indicated in (figure1).

Table1: Sociodemographic characteristics of study participants from Addis Ababa University and St.Paul Hospital Millennium Medical College, Addis Ababa, Ethiopia, 2017.

Variable	Category	Frequency	Percentage
Sex	Male	108	51.4
	Female	102	48.6
Age in year	18	26	12.4
	19	105	50
	20	46	21.9
	21-22	31	15.7
Religion	Orthodox	128	61
	Muslim	38	18.1
	Protestant	38	18.1
	Other	6	2.9
Ethnicity	Amahara	83	39.5
	Oromo	51	24.3
	Gurage	34	16.2
	Tigre	27	12.9
	Other	15	7.2
Maternal education	Illiterate	22	10.5
	Primary school	22	10.5
	Secondary school	35	16.7
	Diploma	50	23.8
	Degree and above	81	38.6
Paternal education	Illiterate	13	6.2
	Primary school	17	8.1
	Secondary school	25	11.9
	Diploma	22	10.5
	Degree and above	133	63.4
Family size	Three	11	5.2
	Four	34	16.2
	Five	72	34.3
	Six	45	21.4
	More than six	48	22.9
Residence of student	Urban area	180	85.7
	Rural area	30	14.3
		N=210	

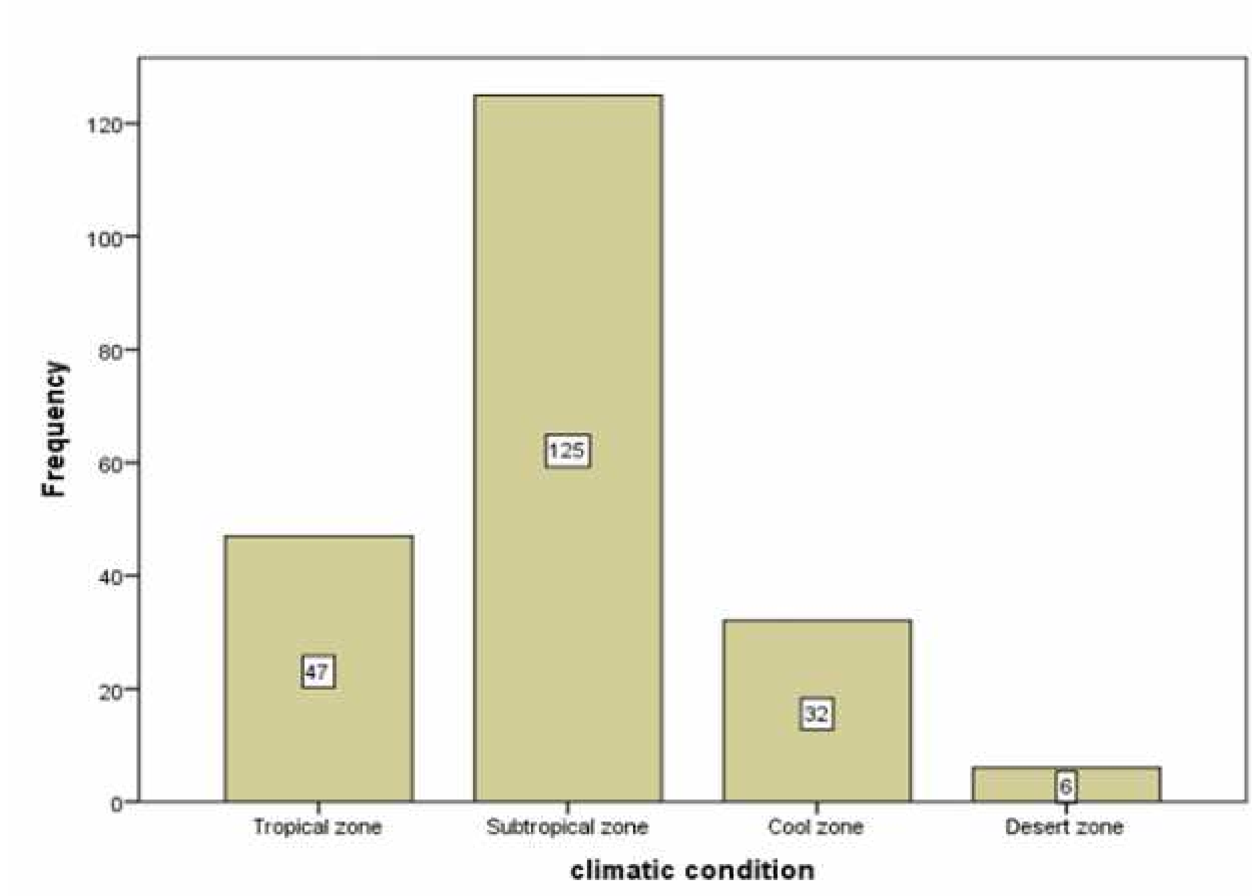


Figure 4: frequency distribution of climatic condition of students came from.

5.2. Descriptive statistics of Morphometric measurements in male and female participants.

Descriptive statistics for stature , hand length and hand breadth in male is shown in Table2.It is observed that stature varies between 160.5cm and 185cm among male participants and it was observed the mean value of stature was 172.715±5.218SD cm. Both right and left hand length ranges between 16 cm and 20.2 cm among male participants. It is also observed that right hand breadth ranges between 6.1cm and 9.7cm,and for left hand between 5.7 cm and 8.8 cm among male participants. Stature varies between 145 cm and 175.20 cm with mean of 160.166±6.078SD cm among female participants. Right hand length was ranged between 13.90 cm and 19.50 cm in female participants. It is also observed that right hand breadth ranges between 5.7 cm and 8.40 cm among female participants.

Table2: Descriptive Statistics of stature, weight, BMI and hand measurement in male and females participants.

Variable	Male(n=108)			Female(n=102)		
	Min	Max	Mean± SD	Min	Max	Mean± SD
Stature	160.50	185.00	172±5.218	145.00	172.2	160.166±6.078
RHL	16.00	20.00	18.048±0.855	13.90	19.50	16.271±0.894
LHL	16.20	20.20	18.119±0.833	14.00	18.30	16.205±0.907
RHB	6.10	9.70	7.947±0.499	5.70	8.40	6.994±0.442
LHB	5.70	8.80	7.775±0.519	5.70	7.70	6.789±0.452
Weight	41.70	90.30	56.606±7.346	27.0	89.90	54.954±9.418
BMI	15.08	33.90	19.979±2.365	12.33	29.49	21.366±3.103

5.3. Stature and hand measurement difference in male and female

Strength of sexual dimorphism in stature and hand measurement were assessed using independent (unpaired) sample t-test .Table3 illustrates the comparison of mean of stature ,weight, BMI, right and left hand measurements between male and female participants. It is evident that overall mean value of stature and all hand measurement of males were larger than females and these all differences were statistically significant ($p<0.05$) for all measurements between males and females.

Table3: Independent sample t-test for comparison of mean of all measurement between male and female participants.

	t-test for Equality of means				
Measurement in cm	t- value	Df	Sig.(2-tailed)	MD	SEED
Stature	16.081	208	0.000	12.55005	0.78042
Right hand length	14.720	208	0.000	1.77735	0.12074
right hand breadth	14.615	208	0.000	0.95387	0.06527
Left hand length	15.939	208	0.000	1.91435	0.12010
Left hand breadth	14.614	208	0.000	0.98510	0.06741
Body weight	4.004	208	0.000	4.6525	1.162
BMI	-3.655	208	0.000	-1.386	0.376

5.4. Assessment of Bilateral asymmetry from right and left hands.

The presence of bilateral asymmetry between right and left hand measurement was assessed for both male and female participants by using paired sample t-test. Table 4 shows t-test for bilateral asymmetry of hand measurement in male and female participants. As table4 indicates, only the hand breadth exhibits statistically significant bilateral asymmetry ($t=5.359$, 7.583 $p < 0.05$), and the mean value of hand breadth is significantly higher on the right side than left in both male and female participants. Bilateral asymmetry of hand length on right and left was statistically insignificant at ($t=1.830$, 1.212 $p>0.05$) in both sexes.

Table 4: Paired Sample t- test for assessing bilateral asymmetry of hand measurement in male and female participants.

Variable	**SD**	**Std. error mean**	**t**	**(95 % CI of MD)**	**p**
Male					
LHL-RHL	0.40382	0.03886	1.830	0.07111(-0.00592,0.14814)	0.070
RHB-LHB	0.33467	0.03220	5.359	0.17259(0.10875,0.23643)	0.000
Female					
RHL-LHL	0.54896	0.05436	1.212	0.06588(-0.04194,0.17371)	0.228
RHB-LHB	0.27146	0.02688	7.583	0.20382(0.1505, 0.2571)	0.000

	Male n=108	**Female n=102**

5.5. Correlation between stature and other measurement among participants.

Pearson's correlation coefficients between stature and other metric measurements for males and females are shown in Table5.All the hand measurements of both sexes show positive statistically significant relation with stature ($p < 0.05$).The r-value between stature and hand measurement ranges from 0.229 to 0.661 for males and from 0.483 to 0.720 for females. BMI was shown statistically in significant p-value ($p>0.05$) for male and female participants.

Table5: Correlation of stature with other variables.

Measurement in (cm)	Male(n=108)		Female(n=102)	
	R	P	R	P
RHL	0.661	0.000	0.676	0.000
LHL	0.588	0.000	0.720	0.000
RHB	0.274	0.004	0.606	0.000
LHB	0.229	0.017	0.483	0.000
BWT	0.39	0.000	0.536	0.000
BMI	-0.112	0.247	0.111	0.266

5.6. Stature estimation from hand measurements.

Multiplication factor, simple linear regression and multiple linear regressions analyses were performed to estimate stature from hand measurements separately from both male and female participants. Multiplication factor for right hand length from male participant was deviated in range of 8.83 cm to10.48 cm with mean of 9.58 cm±0.34SD and mean value of multiplication factor for left hand length was 9.544 cm±0.35SD. Out of total male participants the mean value of multiplication factor was 21.80 cm±1.4SD for right hand breadth and 22.3 cm±1.57SD for left hand breadth. The mean multiplication factor for female's right and left hand length was 9.86 cm±0.39SD and 9.9 cm±0.38SDrespectively; and multiplication factor for right and left hand breadth was 22.96 cm±1.17SD and 23.66 cm±1.42SD respectively.

5.6.1.1. Simple linear regression equation to estimate stature from hand measurement.

Linear regression models were formulated for male and female participants to estimate stature.Table6shows simple linear regression equation to estimate stature from hand measurement of male and female participants. SEE to hand length ranges between 3.933 cm and 4.239 cm in male participants and it ranges between 4.242 cm and 4.503 cm in female participants. R^2-value was larger in hand length as compared to hand breadth but SEE was larger in hand breadth as compared to hand length.

Table6: Simple linear regression equation for estimation of stature from each hand measurement of male and female participants.

Male (n=108)			Female (n=102)		
Equation in cm	R^2	SEE	Equation in cm	R^2	SEE
S=99.909+4.034×RHL	0.437	3.933	S=85.449+4.592×RHL	0.457	4.503
S=105.921+3.686×LHL	0.346	4.239	S=82.05+4.82×LHL	0.518	4.242
S=149.948+2.865×RHB	0.075	5.04	S=101.888+8.33×RHB	0.367	4.859
S=154.83+2.3×LHB	0.052	5.10	S=116.118+6.487×LHB	0.233	5.349

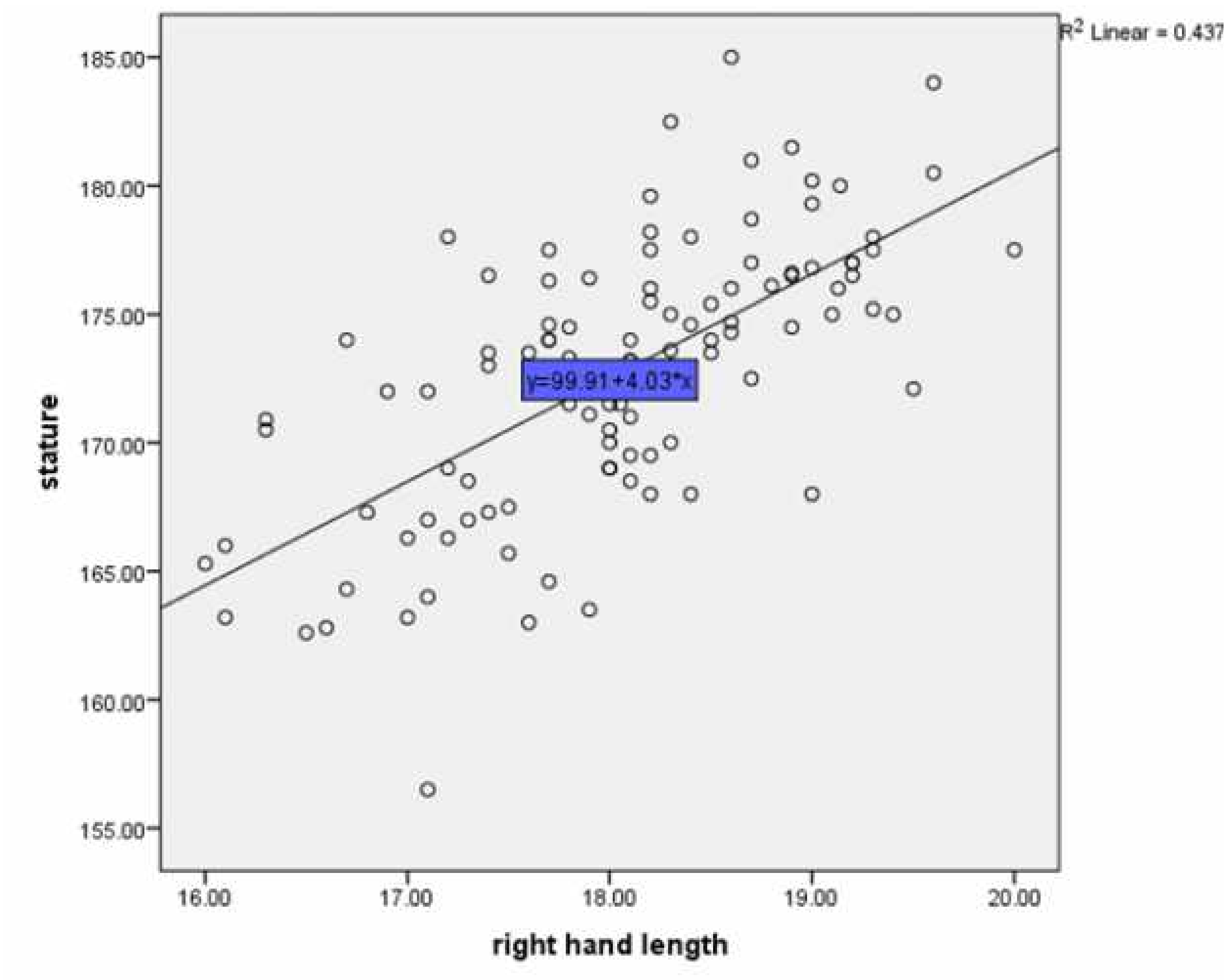
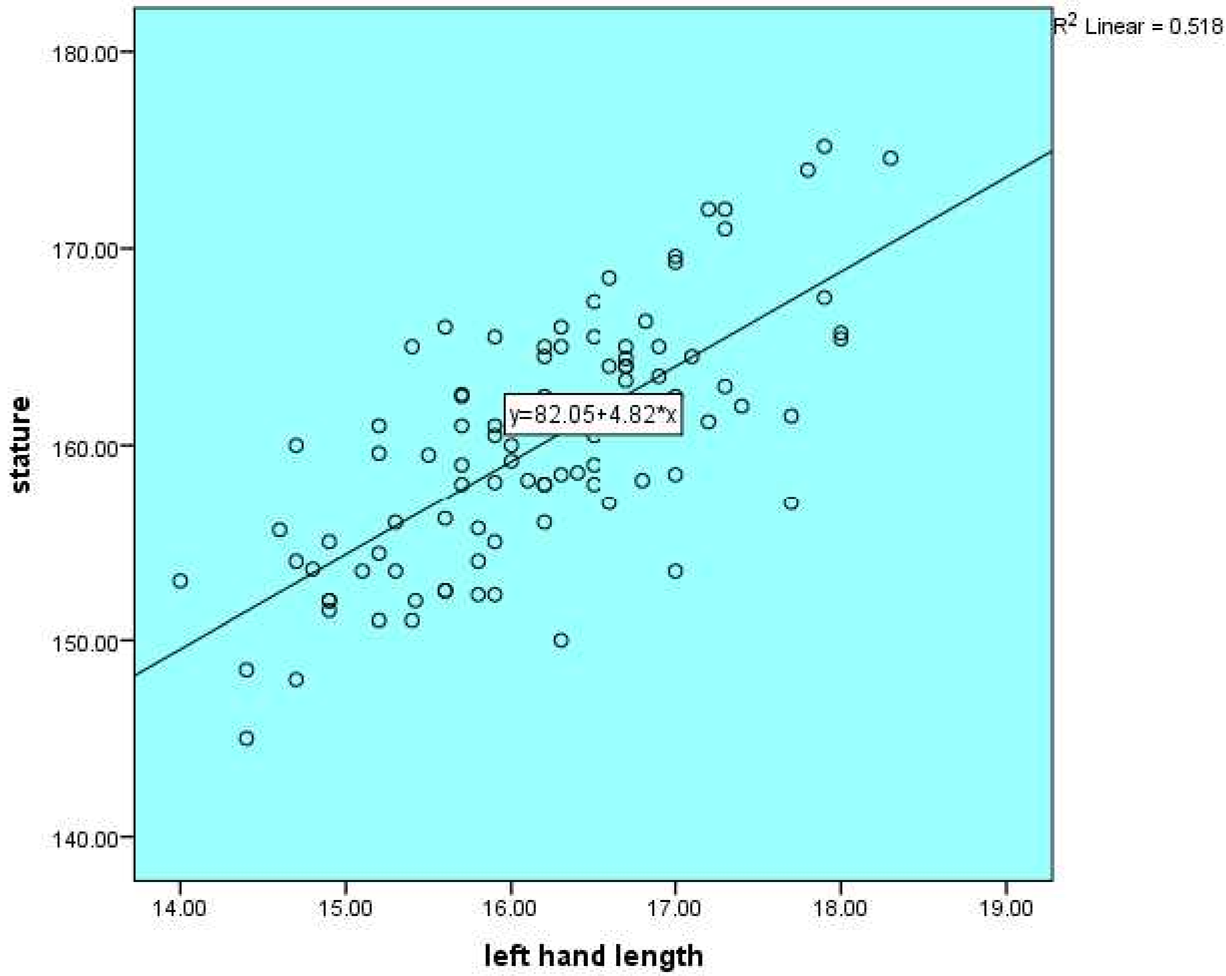


Figure 5.Scatter plot indicate regression line of stature which fit regression model best in male participants.



Y=stature x=left hand length

Figure 6.Scatter plot that indicate regression line of stature which fit regression model best in female participants.

5.6.1.2. Multiple regression equation to estimate stature from hand measurement.

Multiple regression standards were formulated by combination of different hand measurements. Table7 shows the regression formula to estimate stature by combination of four variables from male and female participants. By combination of right and left hand length the R^2 and SEE of estimate was 0.437 and 3.951 cm on male participants. R^2 and SEE of estimate by combination both hand length on female was 0.542 and 4.156.The largest R^2 in female was exhibited by regression equation created by combination of right hand length, left hand length, right hand breadth and left hand breadth. The largest SEE was exhibited from a formula created by combination of right and left hand breadth on both male and female participants.

Table7: Multiple regression formula to estimate stature from hand measurement in male and female participants.

Male(n=108)			Female(n=102)		
Equation in cm	R^2	SEE	Equation in cm	R^2	SEE
99.713+3.968×RHL+0.077 LHL	0.437	3.951	76.150+1.808×RHL+3 .369LHL	0.542	4.156
149.49+2.574×RHB+0.356 LHB	0.076	5.064	102.239+8.722×RHB-0.465LHB	0.368	4.88
100.09_0.052RHB+4.047RHL	0.436	3.952	78.034+4.033RHB+3. 314RHL	0.507	4.31
106.481_0.182LHB+3.733LHL	0.346	4.258	78.062+1.692LHB+4. 358LHL	0.529	4.213
104.981+0.286RHB+3.613LHL	0.347	4.257	75.761+3.325RHB+3. 774LHL	0.552	4.11
100.372+3.978RHL+0.135LHL+ 0.611RHB_0.87LHB	0.414	3.979	72.998+1.294RHL+2. 908LHL+3.275RHB-0.574LHB	0.565	4.09

5.7. Comparison of actual stature and estimated stature.

Students Paired sample t-test was carried out to compare the existence of mean difference between actual stature and estimated stature in both sexes. There is no statistically significant difference ($p>0.05$) between mean value of estimated stature and actual stature in both sexes. As indicated from table 8, t- value was ranged from -0.004 to 0.016 in male and from 0.001 to 0.043 in female participant .The highest and lowest p- value was exhibited with hand length and hand breadth respectively in both sexes.

Table8: paired sample t-test to see existence of mean difference between actual and estimated stature in male and female participants.

Variable	SD	Std.error mean	t	(95% CI of MD)	p-value
Male					
Stature by RHL	3.91492	0.37671	-0.001	-0.00024(-0.74703,0.74656)	1.000
Stature by LHL	4.21948	0.40602	0.016	0.00647(-0.79842,0.81136)	0.987
Stature by RHB	5.01795	0.48285	-0.004	-0.00185(-0.95905,0.95535)	0.997
Stature by LHB	5.07956	0.48878	0.007	0.00345(-0.96550,0.97240)	0.994
Female					
Stature by RHL	4.4811	0.44370	0.001	0.00034(-0.87983,0.88052)	0.999
Stature by LHL	4.22077	0.41792	0.017	0.00711(-0.82192,0.83616)	0.986
Stature by RHB	4.83562	0.47880	0.043	0.02077(-0.92904,0.97058)	0.965
Stature by LHB	5.32291	0.52705	0.004	0.00223(-1.04329,1.0477)	0.997
Male=(108)		**Female=102**			

6. DISCUSSION

The measurement of stature is essential for the calculation of body mass index, which is one of the most commonly used nutritional assessment variable. However, its measurement is not always practical in bedridden individuals, patients that cannot stand due to neuromuscular weakness and for those suffering deformities of the vertebral column. In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposed body remain is vital in establishing the identity of an unknown individual. Therefore, formulae created by current study based on the hand length and breadth may provide an alternative stature predictor under such circumstances.

The present study was undertaken to see the relationship between hand length, hand breadth and stature. Stature growth is related with bone growth and its growth virtually ceases because of epiphyseal fusion, typically at a skeletal age of 15 year in female and 17 year in male (47). Age of study the participants was ranged in between 18-22 years, out of which 50% of sample population was 19 years of age. Different researchers estimate stature from age group that is similar with the current study since it doesn't need extra correction due to stature decline after 30 years old (2, 4,16, 19).Evaluating the presence of sexual dimorphism in all metric measurements is important to decide the need of sex specific equation .The present study documented that the mean value of stature in male was larger with about 12.55 cm as compared to female participants and this difference is statistically significant ($p<0.05$) as indicated from table 3;similarly, mean value of male's hand length was greater than female's hand length and all differences were statistically significant($p<0.05$) . Hand breadth and body weight of male participant also had statistically significant ($p<0.05$) greater mean as compared to female participants. Similar statistical significant mean difference of stature and hand measurement among male and female participants was observed by, Ibegbu et al, Sangeeta et al ,Anwesa et al , Subashri et al (14 , 42, 44,48). The above sexual dimorphism may be from the fact that the age of epiphyseal fusion is about two years later in male; females average peak height velocity of 9 cm/year at age 12 and a total gain in height of 25 cm during the pubertal growth. Males, on average, attain a peak height velocity of 10.3 cm/year two years later than females, and gain 28 cm during pubertal growth. The longer duration of pre-pubertal growth in males, combined with a greater peak height velocity, results in an average adult height difference of 13 cm between male and female as cited by Alen et al (47). The origin of the height difference between males and females is also commonly hypothesized to result from hormonal, environment and sex chromosome composition. Sex steroids such as estradiol and testosterone are highly relevant for growth in closure of growth plates in the long bones and they also affect the secretion of other growth-related hormones such as growth hormone and insulin-like growth factor, therefore it is reasonable to hypothesize that the differential sex steroid patterns may produce at least some part of the sex difference in height (33,35).This is may be the reason why in all measurements except to BMI, males had statistically significant larger mean of stature, hand length, hand breadth and body weight as compared to females. On other hand the mean value of BMI of female was larger than male and the difference was statistically significant ($p<0.05$); similar result was obtained by Nigerian researcher (14).This sexual dimorphism between male and female guide to establish stature estimation formula separately for male and female participants.

Anthropometric measurements are important for calculating BMI of individuals. According to WHO Overweight in adults is generally defined as BMI between 25 and 29.9, and obesity as a BMI >30, BMI less than 18.5 consider as underweighted and BMI between 18.5 and 24.9 is defined as normal. Recently overweight and obesity are major public health problems in worldwide; and it associated with a higher prevalence of a wide range of co-morbidities, such as cardiovascular disease and hypertension (49). Result of current study shows 19.44%, 78.70%, 0.925% and 0.925% of male participants were grouped in category of underweight, normal, over weighted and obese respectively. Of total of female participants 70.58%, 19.6% and 9.8% were normal, underweight and over weighted respectively. Current study indicated that more females were grouped under over weighted sub category as compared to corresponding male participants. Similarly studies done from America shows females are over weighted than males (49); this may be due to reason females tend to accumulate relatively high amount of fat during and after puberty than males as cited by Frank et al (54).

Assessing bilateral asymmetry of hand is important to determine whether hand side specific stature estimation standards should be developed or not. In absence of bilateral difference one single standard can be used for both right and left hand. In present study bilateral asymmetry of hand measurements were analyzed for each sex by using t-test and existence of asymmetry were evaluated. As table4 indicates, only the hand breadth exhibits statistically significant bilateral asymmetry ($t=5.359$, $p < 0.05$), and the mean value of hand breadth is significantly higher on the right side than on the left side. Bilateral asymmetry of hand length on right and left was statistically insignificant at (t=1.830, p>0.05).Bilateral asymmetry of hand measurement was also checked from female participants separately. As indicated from table 4, there was evidence to say bilateral asymmetry is statistically significant (t=7.583, p<0.05) between hand breadth of females and bilateral asymmetry of hand length was statistically not significant (t=1.212, p>0.05).Similarly, Anwesa et al, Partiki et al, Laulathaphol et al (44, 50, 51) found the existence of statistically significant bilateral asymmetry between right and left hand breadth and absence of bilateral asymmetry between right and left hand length. In contrast to the current study, Rajesh et al found the existence of bilateral asymmetry both on hand length and breadth and right side was significantly larger than left side (52). Presence of bilateral asymmetry of handbreadth in present study can be explained by the fact that the subjects may exposed to hard manual work; Bilateral asymmetry of hands is mostly due to more intense physical activity of one side i.e. frequent use of dominant side result in muscle strengthening and greater muscle use and bone development of the respective side, as indicated by Krishan et al in their study (22).

Assessing relationship between hand measurement and stature is important to get evidence that stature can be predicted from hand measurement. Result of this research showed that hand length, hand breadth, body weight of both sexes have statistically significant correlation with the stature (p<0.05).The r-value between stature and hand measurement was ranged from 0.229 to 0.661 for males and from 0.483 to 0.720 for females. Hand length of participants have statistically significant strong relationship with stature in both sexes but hand breadth show statistically significant weak relationship as compare with hand length since its r- value is less than 0.5(table5). A number of other comparable studies such as; Kaur et al, Agrawal et al, Ibegbu et al, Sangeeta Dey et al, Anwesa et al, Ilayperumaet al (1,7,14,42,44,45) report similar findings with current study.The above significant positive relationship of stature and hand measurement provides evidence that stature can be estimated from hand measurement.

Anthropometry is a well-established forensic technique that uses specific body proportions and features to determine stature. Stature is one of the most important and useful anthropometric parameters that define the physical identity of an individual and knowing one’s stature can significantly help to establish his or her personal identity. In present study multiplication factors and regression equations for estimation of stature from hand measurements were formulated for both sexes separately. Multiplication factor is a handy tool and proves vital in situation where the forensic investigator is not well versed with complex mathematical equations or where the investigator is dealing with number of cases like mass disaster or people affected in terrorist attacks (42).Multiplication factor for male participants of the current study was 9.58,9.54,21.8, 22.3 for right hand length, left hand length, right hand breadth and left hand breadth respectively and multiplication factor for female was 9.85,9.89,22.69,22.66 for right hand length ,left hand length, right hand breadth and left hand breadth respectively. Similarly the study done in Gujarati population get 9.32, 9.4 multiplication factor for right hand length of male and female respectively (43).Even if multiplication factor is easy to remember it is less accurate as compare with regression formula to estimate stature; the mean of estimated stature by multiplication factor was highly deviated as compare with estimated stature by linear regression formula. Pervious researchers like Kauret al, Wakode et al, Krishan et al, partiki et al (1,16, 22, 50) also suggested regression formula is more precise to estimate stature than multiplication factor which is in line with current study. In contrast to current study Anwesa et al (44) report multiplication factor as better estimator.

The present study also formulated both linear and multiple regression equations for both sexes separately to estimate stature from hand. The accuracy of simple linear regression equations were assessed by using coefficient of determination (R^2) and standard error of estimate for each parameter of both sexes; as indicated from table6 the R^2 value in male was ranged in between 0.052 - 0.437 and standard error of estimate was ranged in between 3.933 - 5.10. Regression equation that holds the highest R^2 value and lowest SEE is relatively best estimator as compare with lower R^2 and higher SEE. This study documented that the equation formulated by hand length had higher R^2 and lower SEE as compared with hand breadth so using hand length for estimation of stature is better than hand breadth. R^2 value of female participants ranges between 0.233 and 0.518.The highest R^2 and lowest SEE was seen from hand length so equation formulated by hand length is preferred as compared with hand breadth. The results of Krishan et al, Sangeeta et al, Partiki et al (22,42,50) also agreed with the current results since they confirmed hand length is best estimator of stature than hand breadth due to presence of higher R^2 and lower SEE.

The present study also evaluate accuracy of estimated stature by comparing the mean values of estimated and actual stature and t- test was performed to justify the existence of mean difference in both sexes separately. As indicated from table 8, the t- value was ranged from -0.004 to 0.016 in male and from 0.001 to 0.043 in female participant. The mean of estimated stature by using

RHL, LHL ,RHB and LHB was compared with actual stature mean and all estimated stature was not showing the existence of statistically significant mean difference(p>0.05) with actual stature in both sexes. The highest and lowest p- value was exhibited with hand length and hand breadth respectively in both sexes. Statistically in significant mean difference between actual and estimated stature indicates that hand measurement is alternative option to estimate stature by using regression equation. The findings of the present study were found similar to study of Ilayperuma et al, Jitendra et al, Oria et al (45,43,53) since they also compare mean of actual and estimated stature then justified absence of statistically significant mean difference between estimated and actual stature.

7. CONCLUSION

- Stature has statistically significant correlation with hand length and hand breadth.
- Over all mean value of stature, hand length and hand breadth on males were greater than females.
- There is no statistically significant difference between right and left hand length but bilateral asymmetry of hand breadth was statistically significant in both male and female participants.
- Hand length was best estimator as compare with hand breadth in both sexes.
- There was no statistically significant mean difference between estimated and actual stature in both sexes.
- Generally hand length and breadth can be used as predictor of stature when difficult conditions exist to measure stature directly.

8. LIMITATION OF THE STUDY

- Hormonal effect on stature was not assessed due to scarcity of budget and time.
- Lack of literature on estimation of stature from hand length and breadth in Ethiopia becomes challenging to compare with other related investigators in Ethiopia.

9. RECOMMENDATIONS

- Large scale researches should be planned and nationwide guideline should be developed to estimate stature from anthropometric measurement of hand.
- Similar study should be carried out in age group of below 18 at national level.
- It is recommended to carry on further studies on other body parameters to estimate stature.
- Further studies should be conducted to investigate the reasons for bilateral asymmetry of hand breadth.

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ANNEX-I

Consent form

My name is……………………………..and I am masters student of Anatomy in Addis Ababa University and now I am conducting my thesis work on estimation of stature from hand length and breadth. The purpose of study is to assess the relation between stature and hand length. Participants do not face any harm and whatever information you provide it will be kept confidentially by using only code number and will not be shared with anyone else. I hope you participate in study since your information is very important. If you agree I will measure 5-10 minute measurement and allow you to fill the following short questioner. It is based on respondents full consent so, I kindly request you to give the correct answer.

Thank you for your cooperation.

ANNEX-II

Verbal informed consent form

I have been briefly informed about the study and I clearly understood the objectives, the risk and benefit associated with it. Since it doesn't affect my personnel life in any way, I here verbally approve my consent to voluntarily to participate in the study as a study participant.

Participant's code ________________________ Signature:_______________________

ANNEX-III

Questionnaire code-------------

Part-I: Sociodemographic variables

No	Question	Alternative response
1	Sex	1.Male 2.Female
2	Age in year	---------year
3	Residence	1.Urban area 2.Rural area
4	From which region you spent most of your age?	1.Addis Ababa 6.SNNP 2.Amhara 7.Somali 3.Oromiya 8.B/gumuz 4.Tigray 9.Haderi 5.Gambela 10.Afar
5	To which ethnic group do you belong?	1.Amhara 4.Gurage 2.Tigre 5.Somali 3. Oromo 6. Other
6	Educational status of your mother is?	1.Illitrate 2.Primary school 3.Secondary school 4.Diploma 5.Degree holder 6.Above degree holder
7	Educational status of your father is?	1.Illitrate 2.Primary school 3.Secondary school 4.Diploma holder 5.Degree holder 6.Above degree holder

8	Occupation of your parents	1.Farmer 2.Merchant 3.Goverment employer 4.Private sector worker
9	Do you have long standing illness	1.Yes 2.No
10	Climatic condition of your residence is…….	1.Cool zone 2.Subtropical zone 3.Tropical 4.Desert zone

Part II. Morphometric variables cheek list

Variables	Scale	Equipments
Stature	Centimeter	Standiometer
Right hand length	Centimeter	Sliding caliper
Left hand length	Centimeter	Sliding caliper
Right hand breadth	centimeter	Sliding caliper
Left hand breadth	Centimeter	Sliding caliper
Weight	kilo gram	Mechanical balance