Accuracy of Prediction of Stature Based on Hand and Foot Dimension in Bhutanese Students

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Abstract: Stature is the height of the person in the upright posture and a useful anthropometric parameter for identification of an individual the present study was conducted to predict better parameter in the estimation of stature assessing the foot and hand dimensions in international Bhutanese students. The study included 100 subjects (students) randomly taken of the age group of 18-30 years of both sexes and the fetched data was applied to regression analysis to compare true stature and estimated stature. The difference between true stature and estimated stature was not significant in both sexes indicating the high accuracy of prediction. This study provided novel standard data for stature and hand and foot dimensions with a high accuracy of prediction of stature from hand and foot dimensions in Bhutanese students.
Keywords: Dimensions, Estimated stature, Novel study, Regression analysis, True stature.

INTRODUCTION

Identification is the determination of the individuality of a person based on many characteristic features, viz name, age, sex, religion, race, photograph, anthropometry, fingerprints, footprints, DNA typing, congenital or acquired malformations *et al*. [1]. Establishing the identity of an individual from mutilated, decomposed, & amputated body fragments has become an important necessity as of the increasing road accidents, plane crashes, internal wars, natural disasters like earthquake, tornadoes hit, tsunamis and floods recent times due to natural disasters like earthquakes, tsunamis, cyclones, floods *et al*. [2]. Estimation of height as always been a significant parameter for anatomist, anthropologist, Obstetrician and in medico-legal practice [3].

Stature is the height of the person in the upright posture and a useful anthropometric parameter for identification of an individual [4,5]. The stature of an individual is an inherent characteristic which varies with race and is determined by the genetic constitution of a person, geographical location, environment and climatic conditions [6]. As the growth is measured by measuring the height of a person, it can also be assumed to be sum of certain bones of the foot to up to the skull. This relationship is very useful for a medico-legal purpose like identification of a person and determining the racial differences when only parts of the deceased body are available [7,8]. Estimation of stature from incomplete skeletal or decomposing bodies is a recurring theme in physical anthropology and forensic science. In fact, height as a measure of the biological development of both an individual and a population is commonly used in physical anthropology [5,9]. Along with increasing natural calamities and artificial havoc, studies on height, age, and sex of an individual with variable information collected from different systems, organs or its parts are of immense importance in identifying the unknown individuals[6,10-12]. Hand length is a convenient alternative for estimating body height because it is easier to measure than the other anthropometrical indicators used such as length of ulna and tibia[13]. Various studies have been undertaken to establish the relationship of hand dimensions with the height of individual and implicated its use for the personal identification, sexual dimorphism, and racial dimorphism [14].

The main purpose of the study was to estimate the stature of Bhutanese students from the foot and hand dimensions and determine the accuracy of prediction of stature on Bhutanese based on hand and foot dimensions as not much of study was found

available and so would prove useful for further research.

MATERIALS AND METHODS
Study design: Cross Sectional study

Source of data
The proposed study was carried out in the Department of Anatomy, School of Medical Sciences and Research, Sharda University, Greater Noida.

Sample size
Power analysis for a linear regression was conducted in G-POWER to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and a medium effect size ($f^2 = 0.15$) [15]. Based on the aforementioned assumptions, the desired sample size is 55 but 60 was considered as ultimate sample size to accommodate 30 subjects in each gender.(i.e 30 male and 30 female)

Sample technique
Simple Random sampling

Selection criteria
Inclusion criteria
Healthy adults between 18-30 years of age of either sex, not falling into the category of exclusion criteria

Exclusion criteria
Subjects (students) with hand and foot anomalies & PPRD (post-polio residual deformity), subjects (students) with kyphosis & scoliosis, History of hand, foot and spine trauma or surgery and appreciable discrepancies of hand and foot dimensions.

Duration of study: 01/06/2016 to 01/01/2017

METHODOLOGY
An ethical clearance was obtained from the ethical committee of School of Medical Sciences and Research, Sharda University. The purpose of the study was explained and informed consent was obtained from the subjects.

The following dimensions were measured in centimeters based on the specific anatomical landmarks. (International Biology Program—Weiner and Lourie[16].

Body Height (BH): Vertical distance between the vertex and the heel touching the floor.
Foot Length (FL): Most posterior point of the heel to the most anterior point of the longest toe
Foot Breadth (FB): Distance between the surfaces of the 1st and 5th metatarsal boneheads.
Hand Length (HL): Midpoint of radial and ulnar tuberosity to the tip of middle finger.
Hand Breadth (HB): Distance between the head of 5th to 2nd metacarpals.

Body height was measured in standing with barefoot to nearest 0.5 cm, in the anatomical position, and with the head in Frankfurt Horizontal Plane [17].

Measurement for a left foot: In standing subject with body weight rested on the left foot and right leg being slightly bent and drawn backward. Similarly, measurement was taken on right foot [18].

Measurement for left hand: Subject in sitting posture with hand supination, fingers extended and adducted resting on the table. Similarly, measurement was taken on right hand [19].

STUDY ANALYSIS
The data obtained was analyzed via IBM SPSS Statistics Version 21. Differences in stature estimation from hand and foot dimensions were determined using paired and unpaired t-test and Pearson correlation coefficient. Linear regression analysis was used to generate predictive equations of height from hand and foot dimensions. The significance of the test was determined by the following category of p -value. $p<0.001$: Highly significant, $p<0.05$: Significant, $p>0.1$: Insignificant.

RESULTS

Table-1: Observation and comparison of stature in Bhutanese male and female

Variables	Male	Female
Total number	30	30
Mean height ± SEM	166.35±1.26	155.75±0.96

Mean ±SEM (Standard error of mean)

Table-2: Comparison between the true and estimated stature from left hand length (LHL) & breadth(LHB)

Gender	True Stature (cm) ±SEM	Estimated Stature (cm) ± SEM		P - value	
		From LHL	FromLHB	From LHL	From LHB
Male	166.35±1.26	166.32±0.73	166.25±1.92	0.97	0.96
Female	155.75±0.96	155.75±0.91	155.69±2.21	1.00	0.98
Both	161.05±1.04	160.91±0.56	160.99±1.34	0.90	0.97

Table-3: Comparison between the true and estimated stature from right hand length (RHL) & breadth (RHB)

Gender	True Stature (cm) ±SEM	Estimated Stature (cm) ± SEM		P - value	
		From RHL	From RHB	From RHL	From RHB
Male	166.35±1.26	166.33±0.74	166.24±2.13	0.98	0.96
Female	155.75±0.96	155.73±0.84	155.73±2.04	1.00	0.98
Both	161.05±1.04	161.02±0.56	161.95±1.27	0.90	0.97

Table-4: Comparison between the true and estimated stature from left foot length (LFL) & breadth (LFB)

Gender	True Stature (cm) ±SEM	Estimated Stature (cm) ± SEM		P - value	
		From LFL	From RFB	From LFL	From RFB
Male	166.35±1.26	166.19±0.49	166.35±1.50	0.90	1.00
Female	155.75±0.96	155.68±0.72	155.67±1.28	0.95	0.96
Both	161.05±1.04	160.91±0.45	161.00±0.99	0.90	0.97

Table-5: Comparison between the true and estimated stature from right foot length (RFL) & breadth (RFB)

Gender	True Stature (cm) ±SEM	Estimated Stature (cm) ± SEM		P - value	
		From RFL	From RFB	From RFL	From RFB
Male	166.35±1.26	166.29±0.45	166.29±1.37	0.96	0.97
Female	155.75±0.96	155.54±0.68	155.74±1.35	0.85	0.99
Both	161.05±1.04	164.86±0.45	163.89±1.37	0.47	0.92

DISCUSSION

Anthropometric methods have been effective in determining the individual identity by estimating the height from the obtained remains of foot or hand. However, it is applicable for only same ethnic group or race. So many studies on different races are requisite [20]. The present study was carried out in the 60 International Bhutanese Students and all the dimensions were recorded in centimeters.

This study revealed the mean heights±SEM (Standard error of the mean) was 161.05±1.04 for Bhutanese. In this study, the sexual dimorphism was observed among the international Bhutanese students height±SEM (166.35±1.26) of a male in contrast to stature (155.75±0.96) of the Bhutanese female. So on the comparative analysis, we observed that males are taller than females.

The present study was mainly focused over the estimation of stature from hand and foot dimensions and to predict which parameter was most appropriate in estimating the stature. Our studies provided very strong and significant correlations between height and hand & foot dimensions in both the genders.

As per present study in male, the hand length was Bhutanese (right 19.38±0.19 and left 18.64±0.20). Similarly, we also found in female and Bhutanese (right 17.44±0.17 and left 17.45±0.16).

On considering the handbreadth in male we observed Bhutanese (right 8.16±0.09 & left 8.07±0.10).

In the female, it was found handbreadth Bhutanese (right 7.42±0.07 & left 7.41±0.07).

Earlier conducted study in African regarding the measurement of hand was similar to the present study but on difference being at the race chosen [19].

In the present study we had taken the foot dimensions also in the account and observed the foot length in male was Bhutanese (right 23.55±0.36 and left 23.50±0.33). Similarly, foot width was Bhutanese (right 9.51±0.13 and left 9.43±0.13). However, in the case of female foot length Bhutanese (right 8.67±0.12 and left 8.58±0.13) and food width were Bhutanese (right 8.67±0.12 and left 8.58±0.13).

This study provided very strong and significant correlations between height and hand & foot dimensions in both the Bhutanese genders.

For estimation of stature, linear regression equations were derived for hand and foot dimension in both the sexes. On comparing the estimated height with measured true height, the excellent accuracy of the study was judged. It is evident that p-value for hand dimension is more than 0.9 in both sexes. So the difference between estimated stature and true stature is very insignificant. We also observed the p-value for handbreadth is more than hand length, which signifies stature estimation is more accurate with hand breath. On comparing the estimated height from foot dimensions and true stature we could see the p-value is always more than 0.9. Which again confirmed the high

accuracy of prediction of stature also from foot dimensions.

Results of the present study are in accordance with other works done on African and North Indian populations[22, 23]. However, such study on Bhutanese was not found in the record searched, so correlation with earlier studies could not be contemplated. Hence indicating this research to be an absolutely novel.

CONCLUSION

This novel study shows, Bhutanese males are significantly taller than females. The males have longer hand and foot dimensions of both sides than the females. The difference between true stature and estimated stature was not significant and also in both sexes indicating the high accuracy of prediction. We also observed the estimation of height was more accurate with hand and foot breaths compared to lengths. So breadths of hand and foot are a better parameter than a length in the estimation of stature.

Therefore it can be concluded that this study provides standard data for stature and hand and foot dimensions with a high accuracy of prediction of stature from hand and foot dimensions in Bhutanese. This morphometric data and linear regression equations of this study can be used for comparison of similar studies in prevailing context. Further studies on different age group are required for validation of result of this study.

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