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STUDIES ON THE ESTIMATION OF STATURE FROM THIGH LENGTH, LEG LENGTH, FOOT LENGTH AND FOOT BREADTH OF AN INDIVIDUAL

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Abstract

Background: Studies on the estimation of stature from Thigh length, Leg length, Foot length and Foot breadth of an individual are essential study in personal identification. *Aim and Objectives:* This study is to find out correlation between statures with lower limb dimensions in both sexes and gender comparison from an individual in Afe Babalola University Ado Ekiti, Ekiti State, Nigeria. **Material and Methods**: A sample of 271 (112 males; 159 females) individuals, between 16-30 years of ages were grouped into normal, underweight, overweight and obese. The samples from each group were considered and measurements were taken for each of the parameters. Gender differences for the parameters were determined using one way Analyses of variance. Pearson's correlation coefficient (r) was used to examine the relationship between the standing height (stature) and the anthropometric parameters of the lower limbs. All these measurements were done by using standard anthropometric instruments and standard anthropometric techniques. **Results:** The findings of the study indicated that Out of the 112 male students, 60%,10% 18% and 12% were normal, underweight, overweight and obese respectively while out of the 159 female students, 54%,7% 28% and 11% were normal, underweight, overweight and obese respectively. In this study a significant positive correlation is found between stature and the dimensions of tight length (0.32, 0.25), leg length (0.58, 0.47), foot lengths (0.59, 0.35) and foot breadth (0.45, 0.24) in male and female respectively in the normal weight (Table 2). A significant positive correlation is found between stature and the dimensions of tight length (0.75) in female in the underweight group (Table 3). A significant positive correlation is found between stature and the dimensions of tight length (0.52, 0.36), leg length (0.62, 0.61), foot lengths (0.67, 0.48) and foot breadth (0.55, 0.33) in male and female respectively in the overweight (Table 4). A significant positive correlation is found between stature and the dimensions of leg length (0.88), foot length (0.49), and foot breadth (0.71) in female, while the male has strong positive correlation in the dimensions of the leg length (0.67) and foot breadth (0.55), in obese group (Table 5)**. Conclusion:** All lower limb anthropometry parameters are useful estimator of stature provided the subject is of a normal weight with some specific anthropometry in underweight, overweight and obese subjects.

Keywords: Estimation, Hand Length, Foot Length, Individual, Stature.

INTRODUCTION

Estimation of stature is an important parameter in forensic examinations to identify mutilated and skeletal remains [1]. The identification of isolated extremities is an issue of great significance in the investigation of the identity of victims of mass disasters and fatal assaults. In forensic investigations, the dimensions of the hand and foot have been used for determination of sex, age and stature of an individual [2]. Stature reconstruction is important as it provides a forensic anthropological estimate of the height of a person in the living state; playing a vital role in the identification of

individuals [3]. Identification of human remains is a crucial problem and is of immense importance to the forensic expert. Among the various parameters of Identification, individual's stature is an inherent characteristic, the estimate of which is considered to be important in those cases where only fragmentary or mutilated remains of an unknown person are recovered [4]. Many different body parts can be used in the estimation of stature. Certain long bones and appendages can be aptly used in the calculation of height of a person. Many studies have shown the correlation of stature with body appendages [5-7] and with long bones [8]. But there are inter-racial and inter-geographical. There is strong correlation between stature and upper arm limb, Forearm limb, hand length and hand breadth and if any of these measurements is known the other can be calculated. With this objective the present study was designed to correlate the upper arm limb, Forearm limb, hand length and hand breadth with stature of a normal, underweight, overweight and obese individual in both male and female student from Afe Babalola University Ado Ekiti.

MATERIAL AND METHODS

The study comprised of 271 (112 males; 159 females) individuals, between 16-30 years of ages, studying in Afe Babalola University Ado Ekiti, Ekiti State, Nigeria. Out of the 112 male students, 60%, 10% 18% and 12% were normal, underweight, overweight and obese respectively while out of the 159 female students, 54%, 7% 28% and 11% were normal, underweight, overweight and obese respectively To minimize subjective errors all the measurements were taken twice and then mean was taken. The data thus obtained was subjected to statistical calculations using Correlation coefficient which was prepared on the basis of collected data. Graph Pad Prism 5 (Version 5.03, Graph pad Inc.) was the statistical package used for data analysis.

Materials Used for the Research

Improvised Standimeter (for measuring stature),

Cardboard Paper, Long Transparent Ruler,

Writing Materials, Flexible Tape and Sliding

Caliper

Method of Data Collection

Sampling

A sample of Two hundred and seventy one (271) students comprising of forty one percent (41) males and forty nine percent females (49), were randomly selected from the students of Afe Babalola University Ado Ekiti. All participant were healthy students in the age range of sixteen to thirty (16-30) and it was ensured that none has skeletal deformity.

Stature Measurement

The stature is measured as vertical distance from the vertex to the floor with the subject bare footed standing erect on horizontal plane using the standimeter calibrated in (cm). An improvised standimeter constructed as a straight rule starting on a base. The subjects were asked to stand erect with their feet flat on the floor with their heels together and the weight evenly distributed between both feet. The subjects stood erect

with the Frankfort plane (line passing horizontally from the ear canal to the lowest point of the eye orbit) of his head parallel to the floor. Measurement was taken with an anthropometer from the ground to the highest point on the subject's head while firmly contacting the scalp. The measurement was recorded in centimeters [9].

Thigh and Leg Length Measurement

The tight and leg length is measured vertically with the subject standing. The thigh length is taking as straight distance from the Hip to Knee joint, while the leg length is taken as straight distance from the Knee joint to the ankle joint. The reading was in centimeters (cm).

Foot Length and Breadth Measurement

The foot length is measured on the plantar surface with the subject barefooted. The foot length is taking as straight distance from the forefoot at the acropodium to the heel at the pternion. The reading was in centimeters (cm).

Statistical Analysis

Correlation coefficient was prepared on the basis of collected data and their distributions, central tendencies and standard deviations (S.D.) were calculated. Gender differences for the parameters were determined using one way Anova. Pearson's correlation coefficient (r) was used to examine the relationship between four anthropometric parameters and standing height (stature). Graph Pad Prism 5 (Version 5.03, Graph pad Inc.) was the statistical package used for data analysis. Significant difference was set at $p<0.05$.

RESULTS

Table 1: Shows the Gender and Weight Differences of Anthropometry Parameters

		Normal	Underweight	Overweight	Obese
Height (cm)	**Female**	165.7±6.012	166.4±7.418	165.5±7.185	164.8±8.229
	Male	177.6±7.291$^{\alpha}$	177.5±4.949$^{\alpha}$	179.3±8.122$^{\alpha}$	173.0±19.60$^{\alpha}$
Weight (kg)	**Female**	60.23±6.970	48.36±3.668 $^{\beta}$	74.18±6.603 $^{\beta\delta}$	92.56±13.84 $^{\beta\delta¥}$
	Male	68.53±7.303 $^{\alpha}$	54.27±3.524 $^{\beta}$	86.55±8.672 $^{\alpha\beta\delta}$	107.4±27.85 $^{\alpha\beta\delta¥}$
BMI (kg/m^2)	**Female**	21.90 ± 1.761	17.47 ± 0.5811$^{\beta}$	27.07 ± 1.374$^{\beta\delta}$	34.03 ± 3.839$^{\beta\delta¥}$
	Male	21.71 ± 1.710	17.23 ± 1.020 $^{\beta}$	26.88 ± 1.504 $^{\beta\delta}$	36.27 ± 8.494$^{\alpha\beta\delta¥}$
TL (cm)	**Female**	32.53 ± 3.431	34.09 ± 2.427	31.69 ± 3.075	32.83 ± 2.455
	Male	34.90 ± 2.825	35.25 ± 3.088	35.85 ± 4.095$^{\alpha}$	33.86 ± 1.692
LL (cm)	**Female**	44.18 ± 2.993	43.91 ± 2.700	44.50 ± 2.781	43.58 ± 3.219
	Male	46.40 ± 3.222	45.91 ± 2.709	45.48 ± 3.295	45.86 ± 2.735
FL (cm)	**Female**	25.66 ± 1.58	25.36 ± 1.963	25.97 ± 1.153	26.61 ± 2.687
	Male	27.64 ± 1.77$^{\alpha}$	27.00 ± 1.360	29.13 ± 3.479 $^{\alpha\ \beta\delta}$	28.39 ± 1.963 $^{\alpha}$
FB (Inches)	**Female**	3.438 ± 0.2739	3.305 ± 0.3190	3.561 ± 0.2856	3.563 ± 0.2633
	Male	3.817 ± 0.2593	3.669 ± 0.2812	3.936 ± 0.2054	4.081 ± 0.2170
FB (cm)	**Female**	8.733 ± 0.6959	8.395 ± 0.8104	9.045 ± 0.7251	9.051 ± 0.6687
	Male	9.694 ± 0.6593	9.320 ± 0.7138	9.996 ± 0.5214	10.37 ± 0.5504

$^{\alpha}$ = significant different between Male and Female.

$^{\beta}$ = significant different between (Underweight, Overweight, Obese) and Normal.

$^{\delta}$ = significant different between (Overweight, Obese) and Underweight.

$^{¥}$ = significant different between Obese and Overweight.

Table 2: Pearson Correlation between Stature and Some Anthropometry Parameters in Male and Female with Normal Weight.

Variables	Normal			
	Male		Female	
	Pearson Coefficient (r)	P Value	Pearson Coefficient (r)	P Value
Thigh Length (cm)	0.32	0.0088	0.25	0.02
Leg Length (cm)	0.58	0.0000002	0.47	0.000005
Foot Length (cm)	0.59	0.0000001	0.35	0.0009
Foot Breadth (inches)	0.45	0.0001	0.24	0.03
Foot Breadth (cm)	0.45	0.0001	0.24	0.03

In this study a significant positive correlation is found between stature and the dimensions of tight length (0.32, 0.25), leg length (0.58, 0.47), foot lengths (0.59, 0.35) and foot breadth (0.45, 0.24) in male and female respectively in the normal weight (Table 2)

Table 3: Pearson Correlation between Stature and Some Anthropometry Parameters in Male and Female Underweight

Variables	Underweight			
	Male		Female	
	Pearson Coefficient (r)	P value	Pearson Coefficient (r)	P Value
Thigh Length (cm)	0.40	0.22	0.75	0.008
Leg Length (cm)	0.37	0.26	0.088	0.8
Foot Length (cm)	-0.20	0.55	0.39	0.23
Foot Breadth (inches)	-0.17	0.63	0.43	0.19
Foot Breadth (cm)	-0.16	0.63	0.43	0.18

A significant positive correlation is found between stature and the dimensions of tight length (0.75) in female in the underweight group (Table 3)

Table 4: Pearson Correlation between Stature and Some Anthropometry Parameters in Male and Female Overweight

Variables	Overweight			
	Male		Female	
	Pearson Coefficient (r)	P value	Pearson Coefficient (r)	P Value
Thigh Length (cm)	0.52	0.018	0.36	0.016
Leg Length (cm)	0.62	0.004	0.61	0.0000094
Foot Length (cm)	0.67	0.001	0.48	0.00087
Foot Breadth (inches)	0.55	0.01	0.33	0.029
Foot Breadth (cm)	0.55	0.01	0.33	0.029

A significant positive correlation is found between stature and the dimensions of thigh length (0.52, 0.36), leg length (0.62, 0.61), foot lengths (0.67, 0.48) and foot breadth (0.55, 0.33) in male and female respectively in the overweight (Table 4)

Table 5: Pearson Correlation between Stature and Some Anthropometry Parameters in Male and Female Overweight.

Variables	Obese			
	Male		Female	
	Pearson Coefficient (r)	P value	Pearson Coefficient (r)	P Value
Thigh Length (cm)	0.29	0.3	0.33	0.18
Leg Length (cm)	0.67	0.009	0.88	0.0000001
Foot Length (cm)	0.29	0.32	0.49	0.04
Foot Breadth (inches)	0.55	0.04	0.71	0.0009
Foot Breadth (cm)	0.55	0.04	0.71	0.0009

A significant positive correlation is found between stature and the dimensions of leg length (0.88), foot length (0.49), and foot breadth (0.71) in female, while the male has strong positive correlation in the dimensions of the leg length (0.67) and foot breadth (0.55), in obese group (Table 5)

DISCUSSION

This study focuses on the correlation of stature with other indices of the lower limb of the body, which was conducted on some male and female students of Afe Babalola University Ado Ekiti. The result reported in table 1 shows the gender and weight differences among the lower limb anthropometry parameters citing that there is a significant difference between male and female height in the normal weight, underweight, overweight and obese categories.

The result reported in table 2 displays the details of the correlation between stature and lower limb anthropometric parameters in individuals with normal weight. The variables studied showed a significant positive correlation was found between stature and the dimensions of thigh length (0.32, 0.25), leg length (0.58, 0.47), foot length (0.59, 0.35) and foot breadth (0.45, 0.24) in male and female respectively in the normal weight. This means that thigh length, leg length, foot length and foot breadth can be used to estimate stature in individuals with normal weight.

Also, foot length was found to have the highest correlation in males indicating that the foot length provides highest reliability and accuracy in estimating stature among male individuals with normal weight. This is in agreement with Kim et al. (2018) while leg length was seen to have the highest correlation in females which was in contrast to Kim et al. (2018) who found foot length to have the best correlation in both males and females among a Korean population. This contrast could be due to racial differences. Table 3 displays the details of the correlation between stature and lower limb anthropometric parameters in underweight individuals.

The result showed a significant positive correlation between stature and the dimensions of thigh length (0.75) in underweight females citing thigh length as the best predictor of stature for females who are underweight. Table 4 displays the details of the correlation between stature and lower limb anthropometric parameters in overweight individuals. Here, a significant positive correlation is found between stature and the dimensions of thigh length (0.52, 0.36), leg length (0.62, 0.61), foot length (0.67, 0.48) and foot breadth (0.55, 0.33) in males and females respectively citing foot length to be the best predictor in overweight males and leg length to be the best predictor in overweight females.

This finding is slightly in conformity with the work of Ahmed, 2013 who cited leg length and foot length to be the best predictors for stature estimation. In table 5, the details of the correlation between stature and lower limb anthropometric parameters in obese individuals is displayed. The values showed a significant positive correlation between stature and the dimensions of leg length (0.88), foot length (0.49), and foot breadth (0.71) in obese females, while there is a strong positive correlation in the dimensions of the leg length (0.67) and foot breadth (0.55), in obese males. In both obese males and females, leg length shows the strongest correlation citing it as the best predictor for stature in obese individuals.

This finding is slightly in conformity with the work of Ahmed, 2013 who mentioned leg length as one of the best predictors for stature estimation but it deviates slightly as the second-best predictor in his study was foot length but here it was seen to be foot breadth. This deviation may be due to the fact that in this study, this prediction is most reliable for obese individuals only. It was observed that there were significantly positive correlation in the dimension of the leg length, foot length, and foot breadth with stature in the subjects/students with normal body weight and overweight, which was not found to be the same trend in the underweight, and the obese students.

This findings would be a vital tool for scientists in medico-legal cases and anthropologist as well as anatomists in identifying an individual with normal and overweight when only segments and fragments of unknown body part is found, using any of these lower limb anthropometry parameters be it male or female. Also in the underweight group, only the thigh length in female shows a positive significant correlation with stature.

This is an indication that not all the anthropometry parameters of the lower limb can be used to estimate stature in an underweight subject in both male and female.

From this study it may be suggested that in underweight female individual, thigh length can only be used to estimate stature while in male, none of the lower limb anthropometry can be used for the same purpose. For the overweight individual in both male and female, all the lower limb anthropometry parameter can also be used for the estimation of stature.

Furthermore, in obese patient, male or female, all these anthropometry parameters can be used to estimate stature except for thigh length and foot length in the male and thigh length in female subjects.

In conclusion, all lower limb anthropometry parameters are useful estimator of stature provided the subject is of a normal weight with some specific anthropometry in underweight, overweight and obese subjects.

Conflicts of Interest

Authors detected no conflicts of interest

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Reference

1) K. Krishan, T. Kanchan, J. A. DiMaggio. A study of limb asymmetry and its effect on estimation of stature in forensic case work. *Forensic Sci Int* 2010; 200(1- 3):181.

2) I. Ryan, M. A. Bidmos. Skeletal height reconstruction from measurements of the skull in indigenous South Africans. *Forensic Sci Int* 2007; 167(1):16-21.

3) R. G. Menezes, T. Kanchan, G. P.Kumar, P.P.J. Rao, S. W. Lobo, K. Krishan *et al*. Stature estimation from the length of sternum in South Indian males: a preliminary study. *J Forensic Leg Med* 2009; 16(8):441-43.

4) P. N. Patel, J. A.Tanna, S. D. Kalele. Correlation between hand length and various anthropometric parameters. *International Journal of Medical Toxicology and Forensic Medicine* 2012; 2(2); 61-63.

5) K. D. Chavan, S. B. Datir, J. M. Farooqui, H.S. Numan. Correlation of foot length with height amongst Maharashtrian population of India. *J Indian Acad Forensic Medicine* 2009; 31(4):334-37.

6) S. M. Patel, G. V. Shah, S. V. Patel. Estimation of height from measurements of foot length in Gujarat region. *J Anat Soc India* 2007; 56(1): 25-27.

7) S. G. Sanli, E. D. Kizilkanat, N. Boyan, E. T. Ozsahin, M. G. Bozkir, Soames R *et al*. Stature estimation based on hand length and foot length. *Clin Anat* 2005; 18(8):589-96.

8) T. Kanchan, R.G. Menezes, R. Moudgil, R. Kaur, M. S. Kotian, R. K. Garg. Stature estimation from foot dimensions*. Forensic Sci Int* 2008; 179(2-3):241.

9) J. R. Roebuck, A. John. Anthropometric Methods: Designing to Fit the Human Body, Human Factors and Ergonomics Society.1995.

10) O. P. Jasuja, G. Singh. Estimation of stature from hand and phalange length. *J Indian Acad Forensic Med* 2004; 26(3):100-106.