

Table 13: R, R², Adjusted R², and SEE of foot anthropometry in females and males

Variables	Females				Males			
	R	R ²	Adjusted R ²	SEE	R	R ²	Adjusted R ²	SEE
FL	0.264	0.070	0.062	7.443	0.481	0.232	0.223	6.434
BMB					.0220	0.048	0.037	6.953
BMB, FL					0.500	0.250	0.232	6.214

FL= Foot Length, BMB= Bimalleolar Breadth

Table 14: Regression Equations for estimation of height in females of foot anthropometry in females and males

Females		Males	
Regression equation	SEE	Regression equation	SEE
Y = 127.775 + 1.401 (FL)	7.44290	Y =127.687+ 1.667 (FL)	6.43420
		Y =162.475 + 1.518 (BMB)	6.95245
		Y = 123.608 +1.520 (BMB) +1.118 (FL)	6.21064

(FL)= Foot Length, (BMB) = Bimalleolar Breadth SEE= Standard error of estimate, Y= Height

Table 15: Minimum, Maximum, Mean and standard deviations of the predicted Values of height by regression functions with the foot parameters in the females and males

Observed value	Females					Males					
	Min	Max	Mean	SD	N	Min	Max	Mean	SD	N	
Predicted value from:	FL	149.00	190.00	163.18	7.64	123	156.00	190.00	173.66	7.30	88
	BMB	158.60	168.82	163.15	2.03	121	167.68	194.35	173.52	3.51	86
	BMB, FL						171.43	180.07	173.72	1.56	85
	BMB, FL						167.31	192.79	173.72	3.54	85

FL= Foot Length, BMB= Bimalleolar Breadth, SD= Standard deviation

The mean predicted value of Y through the regression function was similar to the mean observed value; however the minimum and maximum value indicated that there were differences in the predicted and observed value. The minimum predicted value overestimates the minimum observed value in the two sexes; the maximum predicted value using BMB in males and FL in the females underestimate the maximum observed value. The rest of the parameter (BMB and FL combined) overestimate the maximum predicted value in the males (Table 15).

5. Discussion

Four dimensions of the foot including height of the subjects were taken. The prediction function was derived through linear regression and multiple regressions for each of the measurement with height, for both gender and for the males and females separately.

In this study, the mean height for the population under study is 167.55± 9.00cm, while that of the female and

male are 163.17 ± 7.64cm, and 173.66 ± 7.30cm respectively.

In sexing the foot parameters, all the variables were highly significant (P< 0.0001). These values were higher in the males than in the females. In support of this is the report by [12] that males had significantly higher values of foot length and foot breadth than females, p <0.001. Male's and female's feet dimensions in this present study has higher mean value than that of Caucasians. This observation must be put into consideration while constructing prosthetic feet and foot orthosis for the Igbos, Nigeria.

The findings of the present study indicate that the correlation 'r' between height and foot measurements were significant for FH, FL, FB and BMB in both genders put together; the highest correlation between the dependent variable and the independent variable (FL) in both gender was 0.555 (P< 0.0001). In the females the correlation 'r' between the dependent variable and the explanatory variables was significant for FL, only. In the males the study revealed that the correlation 'r' between the

dependent variable and the explanatory variable was significant for FL and BMB. The highest correlation 'r' between the dependent variable and the explanatory variable (FL) was 0.41 ($P < 0.0001$). This implies that foot dimensions are proportionate to Y. Therefore an individual with a missing lower extremity should go for foot prostheses or orthoses who's FL is proportionate to Y in other to approximate his/her normal gait.

[13] in their study noted that the correlation 'r' between stature and FL, in males, females and both genders together was 0.716, 0.699 and 0.873 respectively. The highest correlation between stature and the explanatory variables was recorded in both genders together, and this agrees with our findings but our 'r' value (0.555) is lower but highly significant ($P < 0.0001$).

[6] estimated height from measurements of foot length in Gujarat region of India. The mean height and foot length (FL) of the male and female in their study were 170.96cm and 24.44 cm, 156.14 cm and 22.34cm respectively. These values are lower than that gotten in this study. This observation may be due to environmental factors and racial variation.

The value of coefficient of determination R^2 for the multiple linear regression equations with height as the dependent variable and BMB, FB and FL as explanatory variables in both genders together was 0.380. This means that 38% of the total variation in height is explained by the explanatory variables BMB, FB and FL in both genders together.

The values of multiple correlation coefficient R for the multiple linear regression equations for both genders together and males were 0.616 and 0.500 respectively, while the SEE were 7.201 and 6.21. This means that the multiple linear regression models for both genders together as well as for the males fits very well to the observed data (tables 9 and 13) unlike the linear regression model.

The correlation coefficient between height and FH, FL, FB, and BMB were strong in both genders together. It was also significant between height and FL in both males and females and significant for BMB in females only. This means there is a strong bond between height and FH, FL, FB, and BMB and if either of the dimensions is known, the other can be calculated and this would be of utmost important to Anthropologist, Forensic experts, Prosthetist and Orthotist.

[14] in his study to estimate stature from dimensions of hands and feet in North Indian population observed that the correlation between stature and all the measurements of hand and feet were positive and statistically significant. The highest correlation coefficient between stature and foot length and the lowest SEE indicated that the foot length provides the highest reliability and accuracy in estimating stature of unknown individuals. This is in agreement with our finding where the FL in males provided a low SEE; however the multiple regression analysis yielded a much lower SEE using FL and BMB in both genders.

In support of our findings also is the report by [5] that FL displays a biological correlation with height (Y). Y can be estimated from foot when such evidence provides an investigator the best or only opportunity to gauge that aspect of a suspect's physical description. Their study was intended to determine percentages and linear regressions for determining Y from FL for young adult males and females based upon very large U.S Army Anthropometric database.

[6] estimated height from measurements of foot length in Gujarat region of India. Measurement of foot length and body height of 502 students aged 17-22 was taken. The data obtained was analysed and they made attempt to find out correlation and to derive a regression formula between foot length and height. Their result showed a strong correlation between Y and FL; if one of the measurements (FL or total Y) is known, the other could be calculated. Our findings in this present study is congruent with above since FL has significant correlation with Y.

The estimation of stature and determination of gender through foot measurement has been performed [15]. Anthropometric measurements used include: length, width, malleolar height, navicular height measurements of the right and left feet as well as the stature from 249 subjects. From the research, it was observed that while stature estimation dependent on the gender yielded 9 – 10cm errors, those that are independent on gender yielded less than 4cm errors. The study hence concluded by suggesting that stature estimation can be obtained using foot measurements. Our study agrees with this conclusion, in addition, we also regress Y with FH and BMB in both genders.

The foot dimension/measurement used in stature estimation has also been found to vary according to gender. In their study, [16] examined the relationship between stature and foot dimensions among Gujjars in India. Stature, foot length and breadth of 200 subjects comprising of 100 males and 100 females were measured. The study showed that bilateral variation for all measurements except for the foot breadth in males were insignificant. The study also showed that sex differences were highly significant for all the measurement and that the correlation coefficient between stature and the foot measurements were highly significant. More importantly, the study stipulated that the foot length provides the highest reliability and accuracy in stature estimation in males while the foot breadth provides the highest reliability and accuracy in stature estimation in females. Comparing the above with our findings, we noted a highly significant sex differences in FH, FB and FL with males having a high value. The multiple linear regression generated using BMB, FB, and FL provided the highest reliability and accuracy ($R = 0.616$) in both genders together than the simple linear regression generated using FL, ($R = 0.555$).

For the females, the highest reliability and accuracy was obtained using FL, ($R = 0.481$) only, while multiple linear regression generated using BMB and FL provided that of the male's ($R = 0.500$).

Many factors have been documented to influence changes in the size and morphology of foot. Such factors include sex, weight, pregnancy, nutrition, age, genetics, disease, and even environmental conditions [17] [18] [19] [20]. In many of the published works males have significantly high foot length than females. [21] in their study aimed to determine whether proportionate foot length is sexually dimorphic and if so the nature of that dimorphism. They surveyed genetically disparate populations using data from three previous anthropometric studies [10] [22] [23] and foot tracing from the Steggerda Collections at US National Museum of Health and Medicine. Their analyses explored sex differences in the ratio between FL and stature, and tested for nonlinearity. Results although varying in degree across populations, proportionate to stature, female's FL is consistently smaller than male FL; this is in accordance with our findings. However, [24] examined 60 individuals aged 17-18 years and noted proportionate foot length as the same in males and females.

Since the estimation of Y is a very important step in developing a biological profile for forensic identification [25]; the regression equations obtained in this very study were checked for their accuracy by comparing the predicted Y and actual/observe Y. The results obtained here were comparable and has utmost application in forensic investigation, design and production of foot prosthesis and orthoses since the foot anthropometry of the study population has been established and regression equations generated.

Conclusively, if the Y of the subject or any of the foot dimensions (FL, FB, FH, and BMB) is known the other could be generated from the regression equations constructed by applying simple substitution.

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