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Regression Equations for Stature Prediction in Nigerian Hausas, Igbos and Yorubas From Toe Length and Toe-Length Ratios

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Abstract

Introduction: Prediction of stature from different dimensions has considerable forensic value, not only for the identification of human remains but also in developing descriptions of suspects from evidence at scene of crime and in corroborating height estimates from witnesses.

Aims and objectives: The present study deal with stature estimation from toe lengths and toe-length ratios among Nigerians.

Methods: A total of 1574 adult Nigerians consisting of Hausas, Igbos, and Yorubas of equal sex were used in the study. Standard anthropometric methods were used to measure height (stature) and toe lengths (from big toe, 1T to the small toe, 5T for both right [R] and left [L] feet). Ten different toe-length ratios were also calculated. Data were analysed using SPSS version 23 (IBM®Armonk, New York, USA) and Minitab V17 (Minitab® Inc. State College, Pennsylvania) statistical software. Correlation regression model was used to estimate stature. Confidence level was set at 95%; as p-values ≤ 0.05 were considered significant.

Results: The univariate regression analysis showed that the toe lengths were significantly positively correlated and estimates stature (P<0.01), with L.1T had the highest predictive accuracy (R-sq=35.30) and R.5T had the least (R-sq=4.53). The Igbos had the best prediction for stature of the three ethnic groups while the females had the better prediction for stature compared to the males. Toe-length ratios, R2T:5T, R3T:5T, R4T:5T, L2T:5T and L3T:5T of males and R2T:4T, R2T:5T, R3T:5T, L2T:4T, L2T:5T, L3T:4T and L3T:5T of females of the Nigerians significantly correlated positively with stature (P<0.05). While R1T:2T, R1T:3T, R1T:4T, L1T:2T and L1T:3T of males and R1T:2T, R1T:3T, L1T:2T and L1T:3T for females showed significant negative correlation with stature for the general population (P<0.05). However, toe-length ratios prediction accuracy for stature was low (R-sq<2.21). Other ratios did not significantly predicted stature (P>0.05); therefore, there was no regression equation for such variables.

Conclusion: This study estimated stature from toe length and toe-length ratios with the better prediction from the toe lengths. It was sex and ethnic specific therefore its usage in forensic investigation must be specific and peculiar to sex and ethnicity.

Keywords: Anthropometry; Correlation; Regression equation; Sex; Ethnic groups

Introduction

Determination of adult stature is one of the key four factors used in assessing biological profile apart from sex, age and race in forensic anthropology which is important in identification of human remains [1]. Alabi et al. [2] discovered that somatometry of the toe is sexually dimorphic and it is implicated in forensic anthropometry. Prediction of stature from different dimensions has considerable forensic value, not only for the identification of human remains but also in developing descriptions of suspects from evidence at scene of crime and in corroborating height estimates from witnesses [3]. Several researchers have documented the relationship between stature (height) and foot length, hand length shoe print length for different human population using regression analysis and statistics equations were constructed [4,5]. Estimation of stature is not only limited to skeletalise materials but also soft tissues of human remains [6].

Height, like other phenotypic traits, is determined by a combination of genetic and environmental factors. It is sexually dimorphic and statistically more or less normally distributed [7]. Human stature is an anatomical complex of linear dimensions including skull, vertebral column, pelvis, and lower extremities, so that it is assumed that significant association exists between the total stature and these individual body parts [8,9]. It must be noted that and taken in to consideration that the regression equation derived from one population cannot be used for another populations as body dimensions show ethnic variation due to hereditary and environmental conditions [9].

Materials and Methods

A total of 1574 (Hausa=664, Yoruba =490 and Igbo=420) adult Nigerians determined by proportion, using Cochran formulae for infinite population (>10,000); $SS = \frac{Z^2 \times p \times q}{d^2}$ [10]. The studied population consists of equal number of males and females between ages 18 and 65 years which belong to the three major ethnic groups in Nigeria traced to their paternal and maternal grandparents. They were randomly selected from various states in Nigeria using multistage simple random sampling techniques. Written informed consent was taken from each

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Tribe	Hausa Male (N=332) Mean ± S.D	Hausa Female (N=332) Mean ± S.D	t-test (P-value)	Igbo Male (N=210) Mean ± S.D	Igbo Female (N=210) Mean ± S.D	t-test (P-value)	Yoruba Male (N=245) Mean ± S.D	Yoruba Female (N=245) Mean ± S.D	t-test (P-value)
Height (m)	1.71 ± 0.07	1.60 ± 1.35	P<0.01	1.71 ± 0.09	1.61 ± 0.07	P<0.01	1.72 ± 1.54	1.61 ± 0.07	P<0.01
R.1T (mm)	47.15 ± 0.42	42.73 ± 3.37	P<0.01	49.63 ± 4.43	45.73 ± 4.07	P<0.01	47.36 ± 3.76	43.25 ± 3.59	P<0.01
R.2T (mm)	36.62 ± 0.28	30.63 ± 3.65	P<0.01	36.92 ± 5.14	33.31 ± 4.66	P<0.01	35.81 ± 4.67	31.29 ± 4.27	P<0.01
R.3T (mm)	29.42 ± 3.94	24.94 ± 3.28	P<0.01	30.35 ± 4.95	26.63 ± 4.02	P<0.01	29.47 ± 3.97	26.04 ± 0.24	P<0.01
R.4T (mm)	25.64 ± 3.48	21.19 ± 3.22	P<0.01	25.55 ± 3.97	22.85 ± 3.61	P<0.01	25.28 ± 3.69	22.12 ± 3.21	P<0.01
R.5T (mm)	22.52 ± 2.57	18.24 ± 2.48	P<0.01	22.11 ± 3.32	19.72 ± 3.39	P<0.01	22.02 ± 2.84	18.97 ± 2.04	P<0.01
L.1T (mm)	45.79 ± 4.04	42.46 ± 3.13	P<0.01	49.16 ± 39.86	45.33 ± 4.05	P<0.01	46.07 ± 3.70	42.48 ± 3.19	P<0.01
L.2T (mm)	36.34 ± 5.22	30.55 ± 4.02	P<0.01	36.82 ± 5.16	33.05 ± 4.70	P<0.01	35.33 ± 4.56	31.11 ± 4.26	P<0.01
L.3T (mm)	29.38 ± 3.76	24.47 ± 3.34	P<0.01	30.88 ± 4.91	27.27 ± 4.29	P<0.01	29.32 ± 3.83	25.55 ± 3.75	P<0.01
L.4T (mm)	25.51 ± 3.28	21.08 ± 3.09	P<0.01	26.13 ± 3.99	23.05 ± 3.52	P<0.01	25.07 ± 3.62	22.00 ± 3.02	P<0.01
L.5T (mm)	21.97 ± 2.35	18.01 ± 2.35	P<0.01	22.35 ± 3.59	19.76 ± 2.80	P<0.01	21.47 ± 2.40	18.74 ± 2.10	P<0.01

Table 1: Descriptive characteristics of measured parameters of the different tribes.

Variable (Right)	Sex	N	Mean ± S.D	t-value	P-value	Variable (Left)	Sex	N	Mean ± S.D	t-value	P-value
1T:2T	Male	787	1.33 ± 0.14	-9.592	<0.001	1T:2T	Male	787	1.31 ± 0.15	-10.552	<0.001
	Female	787	1.40 ± 0.16				Female	787	1.40 ± 0.17		
1T:3T†	Male	787	1.63 ± 0.20	-8.403	<0.001	1T:3T†	Male	787	1.59 ± 0.20	-11.515	<0.001
	Female	787	1.72 ± 0.22				Female	787	1.72 ± 0.23		
1T:4T†	Male	787	1.90 ± 0.23	-9.014	<0.001	1T:4T†	Male	787	1.86 ± 0.24	-11.417	<0.001
	Female	787	2.03 ± 0.26				Female	787	2.01 ± 0.28		
1T:5T†	Male	787	2.17 ± 0.26	-10.762	<0.001	1T:5T*	Male	787	2.15 ± 0.25	-10.915	<0.001
	Female	787	2.35 ± 0.40				Female	787	2.35 ± 0.44		
2T:3T	Male	787	1.24 ± 0.14	0.323	0.747	2T:3T	Male	787	1.22 ± 0.15	-1.892	0.06
	Female	787	1.23 ± 0.13				Female	787	1.24 ± 0.14		
2T:4T	Male	787	1.44 ± 0.18	-1.57	0.116	2T:4T	Male	787	1.43 ± 0.19	-2.203	0.028
	Female	787	1.46 ± 0.22				Female	787	1.45 ± 0.19		
2T:5T	Male	787	1.65 ± 0.22	-3.558	<0.001	2T:5T	Male	787	1.66 ± 0.22	-3.03	<0.001
	Female	787	1.69 ± 0.30				Female	787	1.70 ± 0.31		
3T:4T	Male	787	1.17 ± 0.12	-1.9	0.057	3T:4T	Male	787	1.17 ± 0.12	-0.373	0.709
	Female	787	1.18 ± 0.13				Female	787	1.17 ± 0.13		
3T:5T†	Male	787	1.34 ± 0.17	-3.957	<0.001	3T:5T†	Male	787	1.36 ± 0.17	-1.6	0.11
	Female	787	1.38 ± 0.22				Female	787	1.38 ± 0.24		
4T:5T‡	Male	787	1.15 ± 0.12	-2.939	0.003	4T:5T†	Male	787	1.17 ± 0.13	-1.47	0.14
	Female	787	1.17 ± 0.14				Female	787	1.18 ± 0.15		

Note: T, Toe; S.D, Standard deviation; M.D, Mean difference; P-value, Probability value (Significant variance at †p <0.01, and ‡p <0.001

Table 2: Sex differences in right (R) and left (L) toe-length ratios.

participant after adequate explanation of the procedures were made. Ethical clearance was obtained from the University of Port Harcourt Ethical Committee with the reference number; UPH/R&D/REC/04. Subjects were free from any apparent symptomatic and general deformities of the spine, toes, and feet such as flat and club feet.

Standard anthropometric procedures were used in the measurements. The height in meter was taken using stadiometer with the precision of 1mm. The toe length in millimeter is the distance between the tips of the toes to the proximal metatarsophalangeal creases using a digital venier caliper (precision 0.01mm). All toe measurements were taken with the respect on sex and on both, left and right feet. Each measurement was taken twice and the average taken as the standard measurements and intra-observer variations were determine using the Pearson's repeatability coefficient' (CR). The toes are 1T for the big toe to the 5T for the 5th or small toe. Ten possible toe-length ratios were calculated from the toe lengths; 1T/2T, 1T/3T, 1T/4T, 1T/5T, 2T/3T, 2T/4T, 2T/5T, 3T/4T, 3T/5T, and 4T/5T (Tables 1 and 2).

Statistical Analysis

SPSS version 23 (IBM® Armonk, New York, USA) and Minitab V17 (Minitab® Inc. State College, Pennsylvania) were the statistical packages used in analyzing the obtained data. Student t-test was used to compare sex differences. Correlation, univariate and linear generalized regression analyses were used to determine the predictability of stature using toe lengths [1T-5T] and toe-length ratios 1T:2T, 1T:3T, 1T:4T, 1T:5T, 2T:3T, 2T:4T, 2T:5T, 3T:4T, 3T:5T and 4T:5T respectively. Confidence level was set at 95%, as P-values ≤0.05 were considered significant.

Results

The univariate regression model for the estimation of the stature for Hausa, Igbo and Yoruba populations showed that all variables (toe lengths) signficantly predicted the male and female stature (P<0.01). However, the correlation of stature and toe lengths were positive and between low to average (R-sq=4.53-35.30) with the best predictor of stature in all the three ethnic groups was L1T with R-sq=23.15 for the males and L1T with R-sq=35.30 for the females. The Igbos had the best prediction for stature and the females better than the males for the three ethnic groups (Tables 3-5).

Variables	Male Stature Prediction (in m)			Female Stature Prediction (in m)		
	R_E	R^2 (%)	P-Value	R_E	R^2 (%)	P-Value
R.1T (mm)	1.195 + 0.0102 R1T	27.6	<0.01	1.195 + 0.0102 R1T	27.6	<0.01
R.2T (mm)	1.354 + 0.0089 R2T	31.42	<0.01	1.354 + 0.0089 R2T	31.42	<0.01
R.3T (mm)	1.367+ 0.0108 R3T	27.6	<0.01	1.367+ 0.0108 R3T	27.6	<0.01
R.4T (mm)	1.400 + 0.0109 R4T	25.94	<0.01	1.400 + 0.0109 R4T	25.94	<0.01
R.5T (mm)	1.378 + 0.0135 R5T	27.4	<0.01	1.378 + 0.0135 R5T	27.4	<0.01
L.1T (mm)	1.175 + 0.0109 L1T	25.54	<0.01	1.175 + 0.0109 L1T	25.54	<0.01
L.2T (mm)	1.385 + 0.0080 L2T	26.51	<0.01	1.385 + 0.0080 L2T	26.51	<0.01
L.3T (mm)	1.362 + 0.0108 L3T	29.82	<0.01	1.362 + 0.0108 L3T	29.82	<0.01
L.4T (mm)	1.401 + 0.0109 L4T	24.06	<0.01	1.401 + 0.0109 L4T	24.06	<0.01
L.5T (mm)	1.370 + 0.0142 L5T	25.97	<0.01	1.370 + 0.0142 L5T	25.97	<0.01

Note: R=Right; L=Left; T=Toes; RF=Right foot; LF=Left foot; T=Toe;R^2=Coefficient of determination; R_E=Regression Equation.

Table 3: Prediction model for stature for the Hausa tribe (with regression equations).

Variables	Male Stature Prediction (in m)			Female Stature Prediction (in m)		
	R_E	R^2 (%)	P-Value	R_E	R^2 (%)	P-Value
R.1T (mm)	1.259 + 0.0091 R1T	22.61	<0.01	1.109 + 0.0115 R1T	33.99	<0.01
R.2T (mm)	1.452 + 0.0071 R2T	18.08	<0.01	1.345 + 0.0090 R2T	25.68	<0.01
R.3T (mm)	1.502 + 0.0069 R3T	16.19	<0.01	1.386 + 0.0096 R3T	25.59	<0.01
R.4T (mm)	1.501 + 0.0083 R4T	14.81	<0.01	1.404 + 0.0106 R4T	21.1	<0.01
R.5T (mm)	1.441 + 0.0122 R5T	17.84	<0.01	1.346 + 0.0150 R5T	26.36	<0.01
L.1T (mm)	1.246 + 0.0095 L1T	23.15	<0.01	1.095 + 0.0119 L1T	35.3	<0.01
L.2T (mm)	1.457 + 0.0069 L2T	17.6	<0.01	1.349 + 0.0089 L2T	25.82	<0.01
L.3T (mm)	1.521 + 0.0062 L3T	12.84	<0.01	1.393 + 0.0092 L3T	24.03	<0.01
L.4T (mm)	1.518 + 0.0075 L4T	12.22	<0.01	1.397 + 0.0107 L4T	22.03	<0.01
L.5T (mm)	1.488 + 0.010 L5T	14.44	<0.01	1.355 + 0.0145 L5T	26.82	<0.01

Note: R=Right; L=Left; T=Toes; RF=Right foot; LF=Left foot; T=Toe;R^2=Coefficient of determination; R_E=Regression Equation

Table 4: Prediction model for stature for the Igbo tribe (with regression equations).

Variables	Male Stature Prediction (in m)			Female Stature Prediction (in m)		
	R_E	R^2 (%)	P-Value	R_E	R^2 (%)	P-Value
R.1T (mm)	1.450 + 0.0056 R1T	11.39	<0.01	1.136 + 0.0115 R1T	32.98	<0.01
R.2T (mm)	1.549 + 0.0047 R2T	12.3	<0.01	1.348 + 0.0091 R2T	29.46	<0.01
R.3T (mm)	1.590 + 0.0043 R3T	7.54	<0.01	1.393 + 0.0094 R3T	22.75	<0.01
R.4T (mm)	1.618 + 0.0040 R4T	5.39	<0.01	1.432 + 0.0093 R4T	17.43	<0.01
R.5T (mm)	1.614 + 0.0047 R5T	4.53	<0.01	1.349 + 0.0149 R5T	24.79	<0.01
L.1T (mm)	1.460 + 0.0056 L1T	10.82	<0.01	1.112 + 0.0123 L1T	31.49	<0.01
L.2T (mm)	1.564 + 0.0044 L2T	10.01	<0.01	1.361 + 0.0088 L2T	26.43	<0.01
L.3T (mm)	1.588 + 0.0044 L3T	7.31	<0.01	1.396 + 0.0094 L3T	22.6	<0.01
L.4T (mm)	1.617 + 0.0043 L4T	5.41	<0.01	1.420 + 0.0099 L4T	18.21	<0.01
L.5T (mm)	1.531 + 0.0087 L5T	10.97	<0.01	1.328 + 0.0163 L5T	25.41	<0.01

Note: R=Right; L=Left; T=Toes; RF=Right foot; LF=Left foot; T=Toe;R^2=Coefficient of determination; R_E=Regression Equation.

Table 5: Prediction model for stature for the Yoruba tribe (with regression equations).

Table 6 represents the correlation (with regression model); the estimation of stature of the Nigerian population using ten (10) Toe-length ratios of both feet. For males, on the right foot (R), significant (negative) correlation was observed between Stature and R1T:2T (R-sq=2.21; *P*<0.01), R1T:3T (R-sq=1.80; *P*<0.01), and R1T:4T (R-sq=0.76; *P*=0.014) while positive significant correlation was observed for R2T:5T (R-sq=0.17; *P*=0.002), R3T:5T (R-sq=1.50; *P*=0.001), and R4T:5T (R-sq=0.52; *P*=0.042).

The left foot (L) showed fewer prediction for stature with negative correlation observed for L1T:2T (R-sq=1.89; *P*<0.01) and L1T:3T (R-sq=0.92; *P*=0.007) while L2T:5T (R-sq=1.03; *P*=0.002) and L3T:L5T (R-sq=.73; *P*=0.018) were positive.

The prediction of stature of female Nigerians; as represented in Table 6 showed that five (5) toe-length ratios on the right foot (R1T:2T [R-sq=2.20; *P*<0.01], R1T:3T [R-sq=0.79; *P*=0.013], R2T:4T [R-sq=0.61; *P*=0.029], R2T:5T [R-sq=1.01; *P*=0.005] and R3T:5T [R-sq=0.60; *P*=0.029]) significantly predicted stature. While on the left foot, six (6) toe-length ratio predicted stature (L1T:2T [R-sq=0.60; *P*=0.03], L1T:3T [R-sq=0.83; *P*=0.01], L2T:4T [R-sq=0.55; *P*=0.037], L2T:5T [R-sq=0.50; *P*=0.047] and L3T:4T [R-sq=1.34; *P*=0.001], L3T:5T [R-sq=0.82; *P*=0.011]). However, the prediction accuracy for stature was low. While other variables did not significantly predicted stature (P>0.05); therefore, there was no regression equation for such variables.

R2T:4T, R2T:5T, R3T:5T, L2T:4T, L2T:5T, L3T:4T and L3T:5T of females correlated positively with stature. While R1T:2T, R1T:3T, L1T:2T and L1T:3T for females showed negative correlation with stature.

Discussion

The increase in the occurrence of mass disasters, has enhance

Variables	Male Stature (in m)				Female Stature (in m)			
	R^2 (%)	R_E	P-value	Inf.	R^2 (%)	R_E	P-value	Inf.
R1T:2T	2.21	1.812 - 0.075 R1T: 2T	< 0.01	*S*	2.2	1.687 - 0.059 R1T: 2T	< 0.01	*S*
R1T:3T	1.8	1.792 - 0.048 R1T: 3T	< 0.01	*S*	0.79	1.650 - 0.027 R1T: 3T	0.013	*S*
R1T:4T	0.76	1.764 - 0.027 R1T: 4T	0.014	*S*	0.13	No Prediction	0.318	*NS*
R1T:5T	0.04	No Prediction	0.581	*NS*	0	No Prediction	0.897	*NS*
R2T:3T	0.01	No Prediction	0.827	*NS*	0.29	No Prediction	0.132	*NS*
R2T:4T	0.19	No Prediction	0.227	*NS*	0.61	1.571 + 0.023 R2T: 4T	0.029	*S*
R2T:5T	0.17	1.656 + 0.035 R2T: 5T	0.002	*S*	1.01	1.568 + 0.021 R2T: 5T	0.005	*S*
R3T:4T	0.37	No Prediction	0.088	*NS*	0.32	No Prediction	0.112	*NS*
R3T:5T	1.5	1.644 + 0.052 R3T: 5T	0.001	*S*	0.6	1.573 + 0.023 R3T: 5T	0.029	*S*
R4T:5T	0.52	1.665 + 0.042 R4T: 5T	0.042	*S*	0.21	No Prediction	0.204	*NS*
L1T:2T	1.89	1.796 - 0.063 L1T: 2T	<0.01	*S*	0.6	1.647 - 0.030 L1T: 2T	0.03	*S*
L1T:3T	0.92	1.766 - 0.033 L1T: 3T	0.007	*S*	0.83	1.649 - 0.026 L1T: 3T	0.01	*S*
L1T:4T	0.24	No Prediction	0.165	*NS*	0	No Prediction	0.908	*NS*
L1T:5T	0.04	No Prediction	0.595	*NS*	0.04	No Prediction	0.584	*NS*
L2T:3T	0.02	No Prediction	0.69	*NS*	0.05	No Prediction	0.514	*NS*
L2T:4T	0.47	No Prediction	0.055	*NS*	0.55	1.569 + 0.025 L2T: 4T	0.037	*S*
L2T:5T	1.03	1.660 + 0.033 L2T: 5T	0.002	*S*	0.5	1.579 + 0.015 L2T: 5T	0.047	*S*
L3T:4T	0.37	No Prediction	0.09	*NS*	1.34	1.536 + 0.058 L3T: 4T	0.001	*S*
L3T:5T	0.73	1.665 + 0.035 L3T: 5T	0.018	*S*	0.82	1.571 + 0.025 L3T: 5T	0.011	*S*
L4T:5T	0.13	No Prediction	0.31	*NS*	0.06	No Prediction	0.485	*NS*

Note: R=Right; L=Left; T=Toe; RF=Right foot; LF=Left foot; R^2=Coefficient of determination; R_E=Regression Equation, Inf., Inference (NS=Not Significant, S=Significant).

Table 6: Toe-length ratios prediction of stature for the Nigerian population (with regression equations).

the necessity to find out how various anatomical parts correlates with stature, age and sex of an individual by examining the different structural dimensions of the anatomical parts. In estimating stature, predictive models are usually developed which are usually derived from univariate or multivariate regressions. However not all derived models can accurately predict stature. Studies have shown that models resulting from using long bones are most accurate in predicting stature (r^2>75) [11-14], while other smaller and irregularly shaped bone predicts less accurately (r^2<50) [15,16]. Although foot parameters for the estimation of stature have been extensively studied [3-4,17,18], little or nothing has been documented about the relationship between the toe lengths, toe-length ratios, and stature.

This study observed that when stature was predicted for different ethnic groups(best predictors for males; Hausa [L.1T*R-sq.=14.17%], Igbo [L.1T*R-sq.=23.15%], Yoruba [R.1T*R-sq.=11.39%] and best predictors for females Hausa [R.2T*R-sq.=31.42%], Igbo [L.1T*R-sq.=35.30%], Yoruba [R.1T*R-sq.=32.98%] and were positively correlated with the toe lengths. Generally, for toe lengths, the Igbo population had the most accurate prediction of stature. This difference can be explained from the variation in mean values observed between the ethnic groups.

Also in this study, when toe-length ratios were used to predict the stature of the general Nigerian population, for males, only 1T:2T, 1T:3T, 2T:5T and 3T:5T on both feet; as well as R1T:4T, R4T:5T and 1T:2T, 1T:3T, 2T:4T, 2T:5T, 3T:5T on both feet with L3T:4T of females produced significant models, however, the correlation coefficients (*r*) was far below 0.10; thus, producing accuracies of less than 10%. Close observation of the predictor variables of stature showed that four parameters (1T:2T, 1T:3T, 2T:5T and 3T:5T) on both feet produced significantly similar predictions of stature for both males and females while two variables dissimilarly produced significant models. This is an indication of uniformity in prediction as well as sex difference for the dissimilar predictor variables for stature. The very low correlation values of the predictor variables are suggestive that despite the significant predictions produced by toe-length ratios, there is no guarantee of reliable predictions.

The identified difference in prediction accuracies across sex and the different ethnic groups for the toe lengths and toe-length ratios is an indication that stature prediction differs across regions, countries, and ethnic groups; as well as sex. This is in line with the findings of Ebite et al. [19]. Researchers have also identified some factors which affect this anatomical data (such as; genetic and intrauterine development, feeding pattern and nutritional qualities, geographical location, physical activity and racial difference [14,20]. Therefore it is most welcomed to define the extent of relationship of the various anatomical parts to stature. Also in view of the fact that populations across the globe have diverse ethnic variations, it is expected that the anthropometric characteristics will differ in different geographical locations; thus, Trotter and Glesser [21] and Arora [14] warns that the estimation models derived for any defined geographical region; as well as ethnic groups should not be applied to another ethnic group even of the same region.

Conclusion

This study observed that all the toe lengths showed positive correlation and significantly predicted stature with better accuracy while some of the toe-length ratios had varied correlations and predicted stature but with low accuracy. However, this requires caution in its usage as it is sex and ethnic specific.

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