

Stature Estimation from Right and Left Foot-Lengths of Young Adults of Berom and Tarok Ethnic Groups of Plateau State, Nigeria

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Abstract: Background: The study on stature estimation from right and left foot-lengths of young adults of Berom and Tarok ethnic groups of Nigeria were aim to determine the correlation of left foot-length (LFL) and right foot-length (RFL) to body height (BH) for crime detection, identification of mass mutilated mixed bodies and industrial production of shoes. Regression formula for stature estimation from foot-length was established.

Methodology: Anthropometric instruments were used for data collection. The total of 2000 subjects living in Jos-North consisting of 1000 Berom with 560(56%) females, 440(44%) males and 1000 Tarok with 580(58%) females and 420(42%) males were used for this study. 18-32years was adopted while 18-22years, 23-27years and 28-32years were used for data collection. Ethical approval was obtained from Ebonyi State University Abakaliki, Nigeria.

Results: The overall Berom males parameter values include LFL=25.610cm, RFL=25.640cm, BH=168.056cm and Berom females parameter values include LFL=23.091cm, RFL=23.370cm and BH=162.59cm. The overall Tarok males parameter values include LFL=25.130cm, RFL=25.160cm, BH=167.049cm and Tarok females parameter values include LFL=22.696cm, RFL=22.902cm and BH=161.96cm. 23-27years subjects had the highest population with 220(50%) Berom males, 304(54%) Berom females, 225(54%) Tarok males and 340(59%) Tarok females. The estimation of stature using foot-lengths had significance at the level of $P < 0.05$.

Conclusion: The right and left foot-length of both Berom and Tarok of ethnic groups of Nigeria correlate to their respective body height for crime dictation, identification of mass mixed mutilated human bodies and industrial production of shoes.

Keywords: Stature estimation, Right foot-length, Left foot-length, Correlation.

1. INTRODUCTION

Stature is the vertical distance between the vertex and the heel touching a flat level surface when in upright posture. Foot-length is the distance from the most prominent part of heel to the most distal part of the longest toe. Since foot ossification and maturation occurs earlier than the long bones therefore stature estimation may be accurately predicted from foot-length [1]. The aim of this study is to correlate stature to foot length for forensic investigation where crime was carried out on bare footed and identification of mass mutilated mixed dead bodies remained for documentation and release to family members for burial. The study will help shoes industries to massively produce shoes that will fit the feet of Berom and Tarok ethnic group of Nigeria. The study was also aim to produce regression formula for males and females of respective ethnic groups.

From time in memorial the relationship between various part of the body to stature estimation had been a great interest to anthropologist [2]. This is due to the catastrophic events that cause massive death of people involved in earthquake, plane crash, bus accident, forest fire among others. In order to help in the identification of correct mutilated body parts most researcher have established a standard for the estimation of stature and length of various bones of the body [3] [2]. Their study was in agreement with this researched work. The study on which body extremities have good correlation to body

height was performed by two independent researchers Ozaslan A and Fessler DMT with their teams and concluded that the lower extremity had good correlation to stature compare to upper extremity of the body [4] [5]. Qamra SR and his team revealed that the identity of criminal may be made possible when foot prints are obtained from crime site so that the stature estimation of the criminal can be calculated using a well established regression formula for people living in a specific geographical location [6]. The study conducted by Swapnil Paliwal and Ashok Kumar Jain on estimation of stature using foot prints length shows that stature can be correlated to foot length with the males appearing taller than the females [7]. Their findings were in consonant with this study.

Furthermore the establishment of standard foot length for stature estimation is very important in forensic medicine for determining the height of an unborn in the womb if the pregnancy was associated with problem for proper diagnosis using ultrasound or computed tomography. The variation in the morphology of human foot may be due to combined effect of lifestyle, heredity and climatic factors [8] [9]. Their research work was in line with this study which will investigate and derive a regression formula for males and females of Berom and Tarok ethnic groups of Nigeria. The study conducted by Devesh VO and his team show that stature and sex can be estimated from foot prints length using gender standard regression formula for people living at a specific region [10]. The estimation of body height from foot length by Edibamode EI and his team shows a high correlation coefficient between body height and foot lengths in males and females, indicating that foot lengths provide a very high reliability and accuracy in the prediction of body height of unidentified males or females of a specific region using regression formula [11]. Their researched was in consonant with this study whose aim is to develop a regression formula for stature estimation from foot lengths of Berom and Tarok ethnic groups of Nigeria. The findings of Krishna Sagar and his team on stature estimation from foot length shows that individual foot length of subjects prove to be useful for stature estimation, offering crucial support for forensic expert and anthropologist [12]. Their study was in agreement with this research work. At the end of this study regression formula was established for stature prediction using foot lengths of Berom and Tarok ethnic groups of Nigeria. This research work is original and has not been published or presented to any journal for publication.

2. MATERIALS AND METHOD

Materials: i. Anthropometer ii. Steel tape iii. Head piece iv. Vernier caliper v. Writing pen vi. Recording exercised book.

Anthropometric Technique of Stature Measurement

The subject who volunteer to participated in the study was told to remove his/her shoes and stand on an anthropometer made up of a calibrated meter rule with moveable head piece attached to a platform stand, place at a level surface. The subject was told to stand at upright posture with hands and legs adducted at anatomical position. The examiner adjusted the head piece to the level of the highest point of the subject head and directly takes the reading of the subject height from the meter rule on which the head, vertebral column and gluteus maximus of the subject rest. A confirmatory test was also conducted immediately using a steel tape to measure the height of the subject from the heel of the foot to the vertex of the head and the result is recorded for comparison. The same procedure was repeated to all the participants of this study.

Anthropometric Technique of Foot Length Measurement

The subject who volunteer to participated in the study was told to remove his/her shoes and place the right foot on an adjustable vernier caliper and ensuring that the subject heel attached to the fixed part of the vernier caliper while the longest toe was touched by the moveable part of the vernier caliper. Measurement was immediately taken and recorded in an exercised book using pen. The subject then remove the right foot and place the left foot on the vernier caliper the method of obtaining the right foot length was apply to get the measurement of the left foot length. The same procedure was used to obtain the right and left foot lengths of all the participants of this study.

Ethical Approval: Ethical approval was obtained from ethics and research committee of Ebonyi State University Abakaliki, Nigeria and was used to obtained permission before the commencement of this study.

Study Populations: The study populations were the people of Berom and Tarok living in Jos-North the capital of Plateau state, Nigeria.

Population Size: The population size of 2000 subjects consisting of 1000 Berom and 1000 Tarok males and females volunteers participated in this study.

Study Age Limit: The selected age limit for participation in this study was 18-29years only.

Duration of Study: The duration of this study was ten months, it commence from 2nd January to 2nd November 2025.

Inclusion Criteria: Only the people with no deformity of head, vertebral column, pelvis, upper and lower limbs were allow to willingly participate in this study.

Sample Technique: Random sampling technique was used to sample the population of this study.

Type of Statistic Used: Comparative statistic was used to direct measurement of parameters of this study.

Data Analysis: The collected data was analyzed using Statistical Package for social Science Version 20.

Study Design: Comparative research design was adopted for this study.

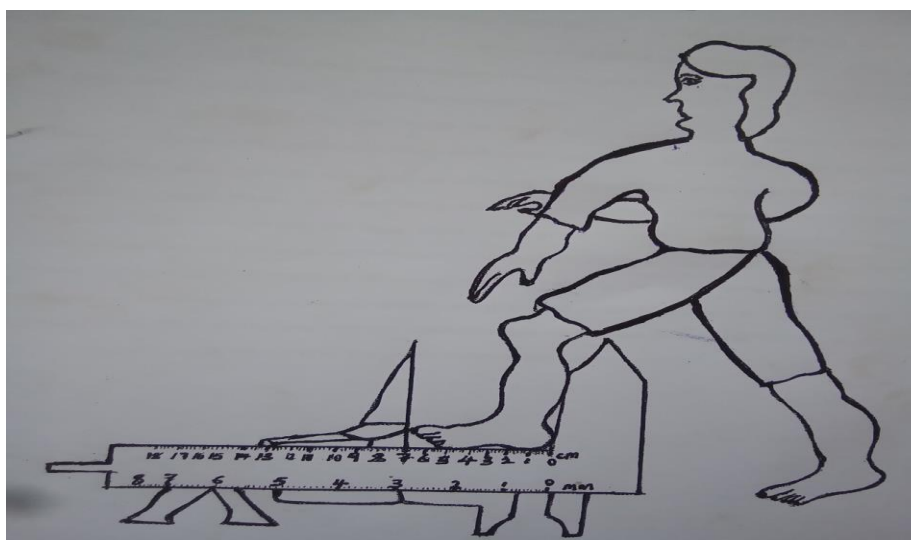


Figure 1. Shows Foot Length Measurement Using Vernier Caliper (Courtesy of Izang Genesis 2026 Free Hand Sketching).

3. RESULTS

Table 1, Shows the Mean, SD, SEM, t-values and P-values of Parameters of Body Height, Right and Left Foot Lengths and Ages of Berom and Tarok Ethnic Groups of Nigeria.

Parameters	Tribes	BM (n=440)			TM (n=420)			BF (n=560)			TF (n=580)			
		Mean	SD	SEM		Mean	SD	SEM		Mean	SD	SEM	t-value	P-value
Age (years)	B	24.575	3.779	0.862		23.590	3.670	0.849		1.437			0.821	
Age (years)	T	23.980	3.298	0.381		23.350	3.190	0.368		0.956			0.340	
LFL (cm)	B	25.610	1.661	0.797		23.091	3.032	0.776		8.230			<0.05	
LFL (cm)	T	25.130	1.180	0.316		22.696	2.552	0.295		7.749			<0.05	
RFL (cm)	B	25.640	1.675	0.618		23.370	1.846	0.639		10.317			<0.05	
RFL (cm)	T	25.160	1.194	0.138		22.906	1.365	0.158		9.836			<0.05	
BH (cm)	B	168.056	12.378	1.758		162.59	10.603	1.765		4.278			<0.05	
BH (cm)	T	167.049	10.896	1.256		161.96	10.122	1.284		3.797			<0.05	

LFL: Left foot-length, RFL: Right foot-length, BH: Body height, B: Berom, BM: Berom males, BF: Berom females, T: Tarok, TM: Tarok males, TF: Tarok females, SD: Standard deviation, SEM: Standard deviation from mean, t-value: test value, P-value: Probability value, <0.05: Statistical significance P-value.

Table 2, Shows the Total Number and Percentage (%) of Males and Females Berom and Tarok Ethnic Groups of Nigeria with Respect to their Total Population and Percentage (%).

Ethnic group	Males	%	Females	%	Population	% population
Berom	440	44	560	56	1000	100
Tarok	420	42	580	58	1000	100

Table 3, Shows the Age Group by Gender, Population and Percentage of Berom and Tarok Ethnic Groups of Nigeria.

Age group range	BMP	% BMP	BFP	% BFP	TMP	% TMP	TFP	% TFP
18-22years	120	27	152	27	114	27	140	24
23-27years	220	50	304	54	225	54	340	59
28-32years	100	23	104	19	81	19	100	17
Total	440	100	560	100	420	100	580	100

BMP: Berom male population, %: Percentage, BFP: Berom female population, TMP: Tarok male population, TFP: Tarok female population.

Regression Formula:

1. Berom Males: $BH = LFL/2X10 + 40.006$ and $BH = RFL/2X10 + 39.856$
2. Berom Females: $BH = LFL/2X10 + 47.135$ and $BH = RFL/2X10 + 45.74$
3. Tarok Males: $BH = LFL/2X10 + 41.399$ and $BH = RFL/2X10 + 41.249$
4. Tarok Females: $BH = LFL/2X10 + 48.48$ and $BH = RFL/2X + 47.43$

4. DICUSSION

Table 1, shows the correlation of right foot length (RFL) and left foot length (LFL) to body height (BH) of Berom and Tarok ethnic groups of Plateau State Nigeria. The Berom males had the mean age of 24.575years with body height of 168.056cm while Berom females had a mean age of 23.59years with body height of 162.59cm. There was no significant difference between the males and females mean age since 0.985years age variation is very small. However 5.466cm difference between Berom males and females' body height is very significant showing that males are taller than females. The Tarok males subjects had mean age of 23.980years with the body height of 167.049cm. While the Tarok females had a mean age of 23.350years with the body height of 161.96cm. The difference in the mean age of Tarok males and females was 0.63years which was not a significance value, but 5.089cm mean body height difference between males and females Tarok was significant, showing that Tarok males were taller than their females. The difference in the mean age between Berom and Tarok males was 0.595years which is not a significant value showing that the males subjects used in this study are almost of the same age group. While 0.24years was the difference in mean age of Berom and Tarok females showing that they are almost of same age group. The difference in the mean body height of Berom and Tarok males was 1.007cm which was a good difference that shows that Berom males are taller than the Tarok males of this study. 0.63cm was the difference in body height of Berom and Tarok females showing that they are almost of the same height. The study conducted by Swapnil Paliwal and his team on estimation of stature using foot prints length shows that males subjects were taller on average than the females [7]. In the research conducted by Rameswarapus Suman Buba and his team on estimation of stature from foot length shows that the average body height of males was higher than that of females [13]. Their finding was in consonant with this study. The study carried out by Anik Agarwal and his team on estimation of stature from foot length in adults students population in North India shows the mean height of males as 165.55cm and 156.70cm females showing that males were taller than the females [14].

Furthermore the Berom ethnic group has the following mean parameter values for left foot length (LFL) and body height (BH): LFL=25.160cm males, LFL=23.091cm females, BH=168.056cm males and BH=162.59cm females. Observation shows that there was significant difference of 2.069cm between the Berom males and females foot lengths showing that males foot length are taller than the females foot length. The correlation of left foot length and body height of both males and females subjects of Berom were statistically significance at the level of $P < 0.05$. Table 1 also shows that the Tarok ethnic group has the following mean parameter values left foot length and body height: LFL=25.130cm males, LFL=22.696cm females, BH=167.049cm males and BH=161.96cm females. Observation shows that there was significance difference of 2.434cm between the mean LFL of males and females of Tarok proving that the males LFL were taller than female LFL. The correlation of mean LFL and BH of Tarok males and females subjects of this study were statistically significance at the level of $P < 0.05$. The study done by Kewal Krishnan and his team on estimation of stature from foot prints and foot outline dimensions in Gujjars, North India concluded that the correlation of foot length to stature was significance at the level of $P < 0.05$ [15]. Their finding was in agreement with this research. The study carried out by Mansur DI and his team on estimation of stature from foot lengths of Napalese population shows that foot length correlate to stature in the identification of individual (Mansur [16]. The study conducted by Amit Magadum and his team on the role of predicting foot length from body height in the population of Belagivi region demonstrated that body height can be successfully predicted from foot length and also said that the study was beneficial to law enforcement authorities and forensic expert in victim identification from mutilated human remains of Belagavi region [17]. Their research work was in consonant with this study.

In addition the Berom ethnic group has the following mean parameters for right foot length and body height: RF=25.640cm males, BH=168.056cm males, RFL=23.370cm females and BH=162.59cm females. The Berom males' foot length was longer than the females' foot length by 2.27cm. The correlation of right foot length to body of Berom males and females was statistically significant at the level of $P < 0.05$. Table 1, also shows that the Tarok ethnic group has the following mean parameters: RFL=25.160cm males, BH=167.049cm males, RFL=22.906cm females and BH=151.96cm females. The right foot length of Tarok males was longer than that of the females with 2.254cm. The correlation of right foot length and body height of Tarok males and females was significant at the level of $P < 0.05$. The study made by Kanwal Kamboj and his team on the correlation between foot length and body height of the subjects under their research shows that the foot length in males and females have hight correlation to stature with minimum standard error in mean [18]. Their finding was in agreement with this study. The independent study carried out by Deopa Deepa on the estimation of stature from foot length of Uttarakland region shows that foot length is a better identity for stature which play an important role in forensic medicine that help in the determination of body height of an unborn baby through ultrasound or computed tomography measurement of foot length of the child in womb [19]. The need for many studies to be conducted in different regions of a specific geographical location is of important because it can lead to the generation of a standard data base for foot length of the people of that location which can help in crime detection when committed on bare feet and in the identification of mutilated body remains [20], [21], [22].

Table 2, shows that the total of 2000 subjects participated in this study consisting of 1000 Berom and 1000 Tarok ethnic groups of Nigeria. The population of Berom males and females were 420 and 580 respectively. Observation shows that the population of females was higher than that of males of this study. The study conducted by Devesh VO and his team clearly shows that a regression formula when establish can help in the determination of stature from foot prints length by gender with high prediction accuracy that can help in crime detection and identification of remains of mutilated bodies [10]. The finding of Alabi SA and his team on estimation of stature from toe length of Nigerian Hausa, Igbo and Yoruba clearly shows that regression formula can be use in the estimation of stature and sex using foot length [23]. While Table 3, shows that the mean age range 23-27years of both Berom and Tarok people have the highest percentage population used in the study. The result are as follow, 220(50%) Berom males, 304(54%) Berom females, 225(54%) Tarok males and 340(59%) Tarok females. This show the reason why the overall age of subjects used in this study are within the age limit of 23.50-24.575years.

5. CONCLUSION

The right and left foot lengths of males and females Berom and Tarok ethnic groups of Plateau state, Nigeria have a very good correlation to their respective stature with minimum standard deviation for forensic investigation of crime, identification of mass mutilated mixed bodies in which the lower limb was cut away from the main body of an individual and industrial production of large quantities of shoes using the standard values establish through research to maximize profit. A regression formula was successfully developed for Berom and Tarok ethnic group of Nigeria.

6. RECOMMENDATION

The author recommended that more study should be carried out on all the ethnic groups of Plateau state Nigeria in order to develop a data base for the young adults of Berom and Tarok ethnic groups of Nigeria.

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Conflict of Interest: The author declared that there was no conflict of interest with respect to this study.

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