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Estimation of Stature Using Selected Hand Dimensions among Adolescents of Fulani Ethnic Group in Yola, Nigeria

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Abstract

Stature (body height) is an important and useful anthropometric parameter for identification of an individual. 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. The objectives of this study were to determine sex differences among the participants from all the measured parameters (hand length, palm length and the lengths of the second, third, fourth and fifth digits), find the correlation between stature and all the measured hand dimensions and further establish linear regression equations, regression line graph and determine the accuracy rates (percentage) of the estimates by calculating the estimated stature from the actual stature. A total of 407 (181 males and 226 females) adolescent's participants who were Fulani origin by both parents and grandparents attending the selected secondary schools and met all the inclusion criteria were selected and measured for each of the parameters. Stature was measured using stadiormeter and vernier caliper was used to measure the hand parameters. The data were analysed using IBM SPSS Statistics version 20. $P < 0.05$ was considered significant. All the parameters showed significant correlation with stature at $P < 0.01$. Hand length showed the highest correlation value ($r = 0.668$), while fifth digit length had the least correlation value ($r = 0.527$). This study shows that stature and hand dimensions are sexually dimorphic with male participants having higher values of the measured parameters than the female participants. linear regression equations were formed for each of the parameters. Hand dimensions are considered as good source for estimating stature in forensic practice among Fulani adolescents of Yola origin, Adamawa State of Nigeria.

Keywords: Stature, Fulani, Adolescents, Hand dimensions.

INTRODUCTION

Anthropometry is an early tool of physical anthropology; it has been used for identification, for the purposes of understanding human physical variation in palaeoanthropology and in various attempts to correlate physical with racial and psychological traits (Jaydip & Shila, 2008). It is often viewed as a traditional and perhaps the basic tool of biological anthropology but it has a long tradition of use in forensic sciences especially in the discipline of forensic medicine. The ultimate aim of using anthropometry in forensic medicine/science is to help the law enforcement agencies in achieving 'personal identity' in cases of unknown human remains to describe the remains in such terms. Forensic anthropometry determination has provided means to estimate the stature of individuals from body parts (Badamasi *et al.,* 2024). Stature or body height is one of the most essential and potential anthropometric parameter which determines the physical identity of an individual. It is the natural height of a human or animal in an upright position, it varies according to age, sex, population and individual development. Stature serves as a significant indicator of growth and development and it is used in the clinical setting for nutritional and health research. 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 (Ozaslan *el at.,* 2012). The measurements of body parts can change with alterations in size of the organs involved or general body size. This observation crystallized into the concept of allometry, which was defined by Levinton as the relationship between changes in shape and overall size. In forensic investigations, the dimensions of the hand have been used for determination of sex, age and stature of an individual (Rastogi *et al.,* 2009).

Stature reconstruction is important as it provides a forensic anthropological estimate of the stature of a person in the living state; playing a vital role in the identification of individuals (Malina, 1991). Identification of human remains is a crucial problem and is of huge importance to the forensic expert. Many studies have shown the correlation of stature with body appendages (Ryan & Bidmos, 2007) and with long bones (Kanchan & Krishan, 2011). Many different body parts can be used in the estimation of stature, certain long bones and appendages can be used in the calculation of stature of a person such as femur, tibia, humerus, radius and very little data is available on previous work done for calculation of stature from hand dimensions.

Hand anthropometry is useful for determining various aspects of industrial machineries so as to design the equipment and machines for better efficiency and more human comfort. Hand as an organ of the body performs many significant functions in the investigation and operation of the environment. Yet, in evolutionary terms the hand represents one of the most primitive body structures. By retaining five independent and mobile digits, the human hand has changed very little from the pattern of the earliest pentadactyl vertebrates (Krishan & Sharma, 2007). The hand posture and the related grip strength are influenced by the shape of the handle and the hand size. Thus, the hand is often thought of as one of the most distinctly human aspects of Anatomy (Ibegbu *et al.,* 2014).

This study looks into the possibility of estimation of stature from the hand dimensions very few anatomists are involved in this type of study in the North eastern part of Nigeria. So there is need to share the knowledge of the outcome of the research with other Anatomists. The most interesting part of this study is regional and racial considerations while predicting the stature measurement from different hand dimensions. The diversity of Nigerian population provides a unique opportunity to study the morphogenetic variations amongst the endogenous sub-populations consisting of different tribes, languages and religious beliefs living in different geographical and ecological conditions.

MATERIALS AND METHODS

Ethics clearance:

The research protocol was submitted to the research ethics committee of Bayero University Kano, faculty of basic medical sciences for assessment and certification. An introductory letter was obtained from the department and presented to the post primary schools management board Yola; ethical permit was obtained from the board and presented to the school's management, approval was obtained from the school's management and formal informed consent was also obtained from students and parent teachers association (PTA) of the schools before collection of data. The current study involves healthy adolescent participants, data were obtained from 407 (181 males & 226 females) participants that were selected and each participant was screened based on the study inclusion criteria.

Inclusion criteria

i. Participants that were consented to participate.
ii. Participants within the age group of 14 to 17 years.
iii. Participants that were Fulani by ethnic group from Yola.
iv. Participants without any physical deformity.

Each of the potential study participant was informed about the study's aim and objectives. Further clarification as relates to the study were done before participants were asked to give a written informed consent. A proforma was completed for all participants that included age, sex, tribe, stature (measured as the vertical distance from the vertex to the plantar surface of the heel whiles the subject standing erect on the horizontal resting plane of the stadiometer), hand length (measured on the palmer surface of the hand as the distance from the midpoint of the distal crease of the wrist to the tip of the middle finger using digital Vernier caliper), palm length (measured on the palmer surface of the hand as the distance from the most distal flexion crease of the wrist to most proximal flexion crease of the middle finger using digital Vernier caliper), lengths of the 2nd finger (measured on the palmer surface of the hand as the distance from the most proximal crease of the index finger to the projecting point of the tip of the finger using digital Vernier caliper), 3rd finger (measured on the palmer surface of the hand from the distance of the most proximal flexion crease of the middle finger (3rd digit) to the tip of the finger using digital Vernier caliper), 4th finger (measured on the palmer surface of the hand from the distance of the most proximal flexion crease of the middle finger (3rd digit) to the tip of the finger using digital Vernier caliper) and 5th finger (measured on the palmer surface of the hand from the most proximal flexion crease of the little finger (5th digit) to the tip of the finger). The materials used for this study were stadiometer (206IN, Seca, USA) and a digital Vernier caliper (Neiko 01407A, Stainless Steel, China).

Statistical analysis

Data were expressed as mean ± standard deviation. Student's t-test was used for differences between male and female participants in all the parameters measured. Pearson correlation was applied to test relationship between stature and each of the measured parameters, linear regression equations were applied to estimate stature in both male and female participants from the various parameters measured. The data were analysed using IBM SPSS Statistics version 20. p <0.05 was considered significant.

RESULTS

Table 1: Shows the descriptive statistics of the measured anthropometric parameters for both male and female participants among the adolescents of Fulani ethnic group in Yola (n=407)

Parameters	Mean± SD	Minimum	Maximum
Age (yrs)	16.19 ± 1.23	14.00	18.00
Stature (cm)	160.47 ± 7.62	142	184
Hand length (cm)	17.86 ± 1.03	15	21
Palm length (cm)	10.15 ± 0.65	8. 00	12
Second digit length (cm)	6.80 ± 0.57	5. 00	8. 00
Third digit length (cm)	7.76 ± 0.60	6. 00	9. 00
Fourth digit length (cm)	7.18 ± 0.55	6. 00	9. 00
Fifth digit length (cm)	5.66 ± 0.57	4. 00	7. 00

Table 2: Shows the sex differences in all the measured anthropometric parameters for both male and female participants among the adolescents of Fulani ethnic group in Yola.

Parameters	Male (n=181)	Mean ± SD	Min	Max	Female (n=226)	Mean ± SD	Min	Max	t	*p*-value
Age (yrs.)		16.43 ± 1.32	14	18		16.00 ± 1.13	14	18	3.55	<0.01
Height (cm)		162.99 ± 9.44	142	184		158.45 ± 4.91	144	170	6.25	<0.01
HL (cm)		18.16 ± 1.13	15	21		17.62 ± 0.88	16	20	5.37	<0.01
PL (cm)		10.30 ± 0.70	8	12		10.41 ± 5.55	9	93	4.04	<0.01
2nd DL (cm)		6.85 ± 0.57	6	8		6.75 ± 0.56	5	8	1.75	0. 08

Parameters	Male (n=181)	Mean ± SD	Min	Max	Female (n=226)	Mean ± SD	Min	Max	t	*p*-value
3rd DL (cm)		7.92 ± 0.62	7	9		7.63 ± 0.55	6	9	5.06	<0.01
4th DL (cm)		7.29 ± 0.58	6	9		7.09 ± 0.51	6	8	3.70	<0.01
5th DL (cm)		5.81 ± 0.57	5	7		5.54 ± 0.54	4	7	4.75	<0.01

HL=hand length, PL=palm length, DL=digit length, SD=standard deviation, Min=minimum, Max=maximum.

Table 3: Shows the coefficient of correlation (r) values of the measured anthropometric parameters for both male and female participants among the adolescents of Fulani ethnic group in Yola.

Gender	Parameters	r	*p*-value
Male (n=181)	Hand Length (cm)	0. 715	<0.01
	Third Digit Length (cm)	0. 655	<0.01
	Second Digit Length (cm)	0. 652	<0.01
	Fourth Digit Length (cm)	0. 645	<0.01
	Palm Length (cm)	0. 641	<0.01
	Fifth Digit Length (cm)	0. 595	<0.01
Female (n=226)	Hand Length (cm)	0. 551	<0.01
	Palm Length (cm)	0. 539	<0.01
	Third Digit Length (cm)	0. 442	<0.01
	Fourth Digit Length (cm)	0. 415	<0.01
	Second Digit Length (cm)	0. 406	<0.01

Gender	Parameters	r	*p* -value
	Fifth Digit Length (cm)	0. 328	<0.01

Table 4: Shows the linear regression equations of both sexes for stature estimation from the measured anthropometric parameters among adolescents of Fulani ethnic group in Yola.

Gender	Parameters	B	Linear regression equations	r	SEE	*P* -value
Male (n=181)						
	HL (cm)	6. 327	ST = 48.312 + 6.327(HL)	0. 715	6. 638	<0.01
	3rd DL (cm)	11.325	ST = 73.790 + 11.325(2nd DL)	0. 655	7. 169	<0.01
	2nd DL (cm)	12.093	ST = 79.614 + 12.093(3rd DL)	0. 652	7. 195	<0.01
	4th DL (cm)	12.005	ST= 75.274 + 12.005(4th DL)	0. 645	7. 253	<0.01
	PL (cm)	9. 394	ST = 66.545 + 9.394(PL)	0. 641	7. 281	<0.01
	5th DL (cm)	11.372	ST= 97.065 + 11.372(5th DL)	0. 595	7. 628	<0.01
Female (n=226)						
	HL (cm)	3. 159	ST= 102.699 + 3.159(HL)	0. 551	4. 117	<0.01
	PL (cm)	5. 120	ST = 107.192 + 5.120(PL)	0. 539	4. 157	<0.01
	3rd DL (cm)	4. 844	ST= 121.342 + 4.844(3rd DL)	0. 442	4. 425	<0.01
	4th DL (cm)	4. 681	ST= 125.434 + 4.681(4th DL)	0. 415	4. 490	<0.01
	2nd DL (cm)	4. 535	ST= 127.836 + 4.535(2nd DL)	0. 406	4. 509	<0.01
	5th DL (cm)	3. 821	ST= 137.330 + 3.821(5th DL)	0. 328	4. 662	<0.01

ST=stature, HL=hand length, PL=palm length, DL=digit length, r=coefficient of correlation, SEE=standard error of estimate.

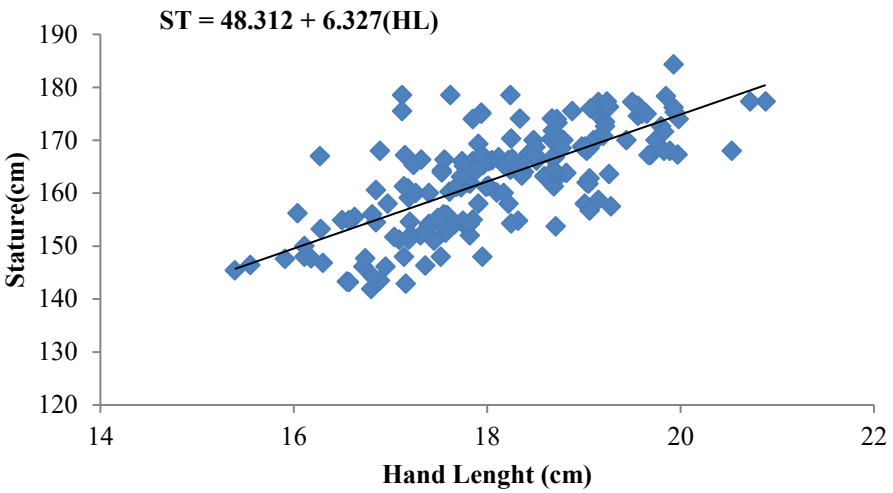

Figure 1: Male regression line of stature on hand length.

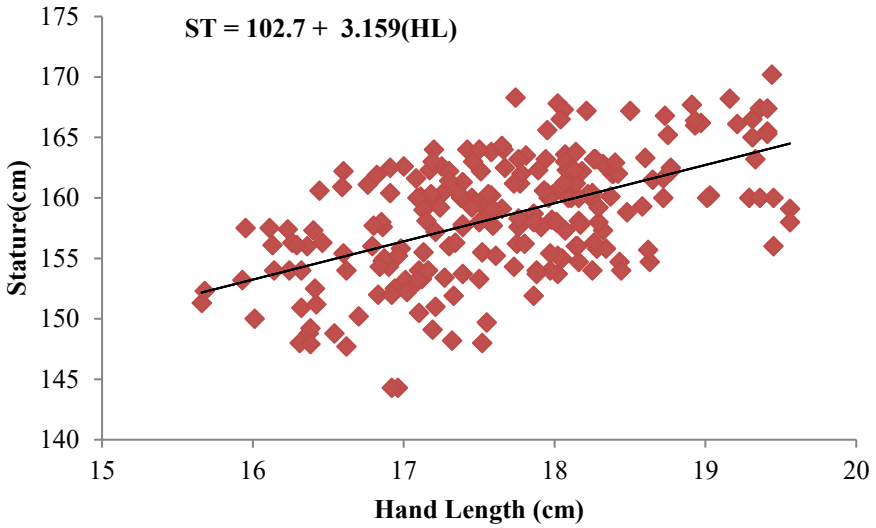

Figure 2: Female regression line of stature on hand length.

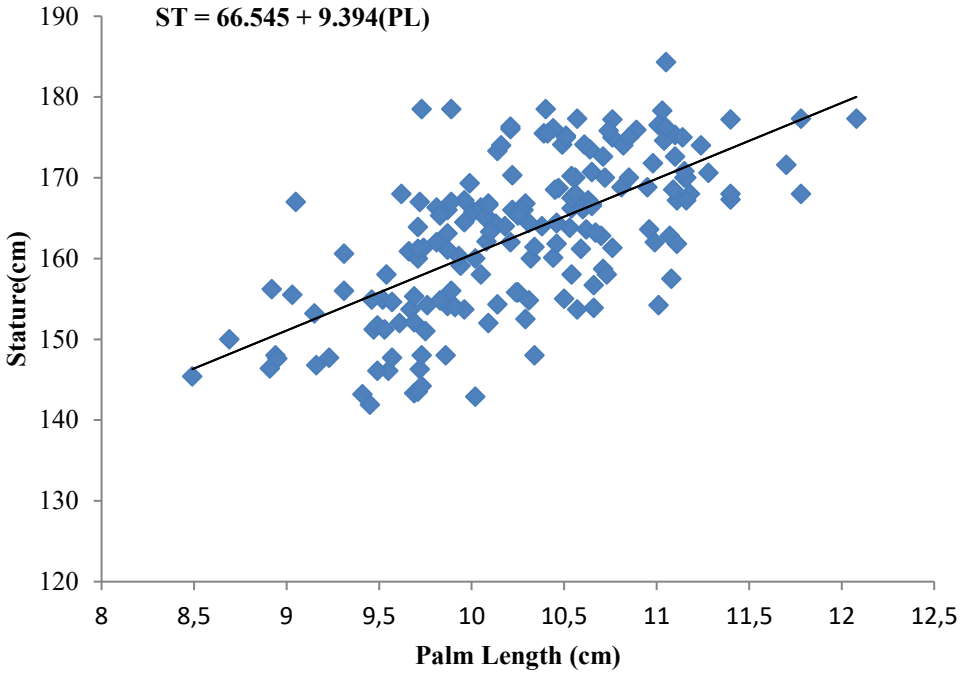

Figure 3: Male regression line of stature on palm length.

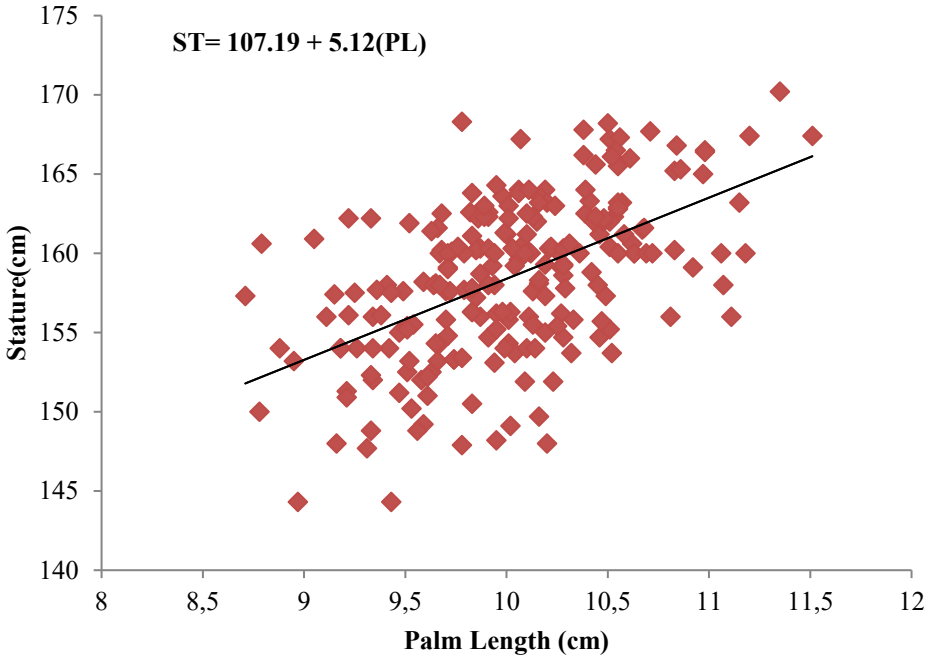

Figure 4: Female regression line of stature on palm length.

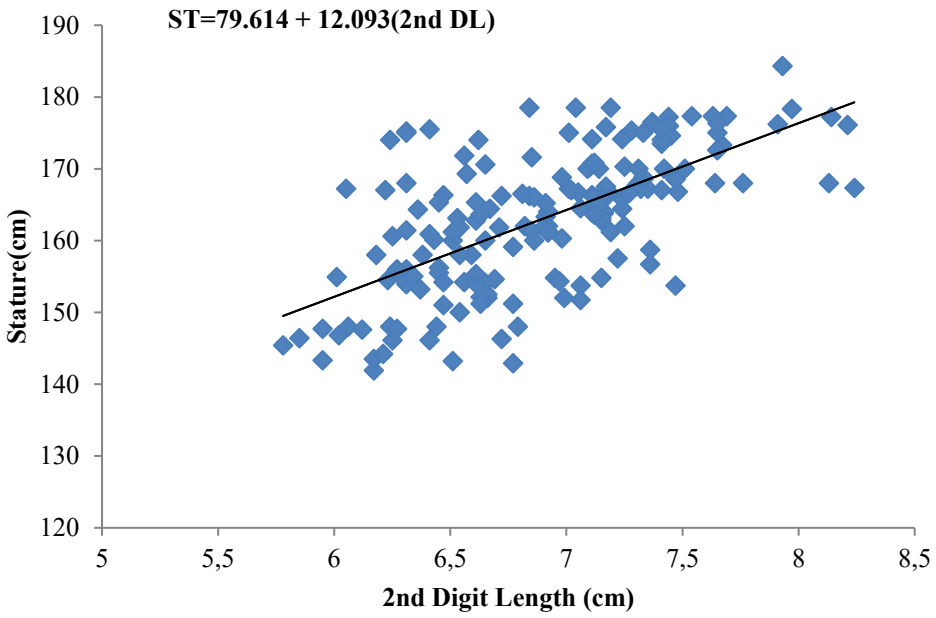

Figure 5: Male regression line of stature on index finger (2nd digit) length.

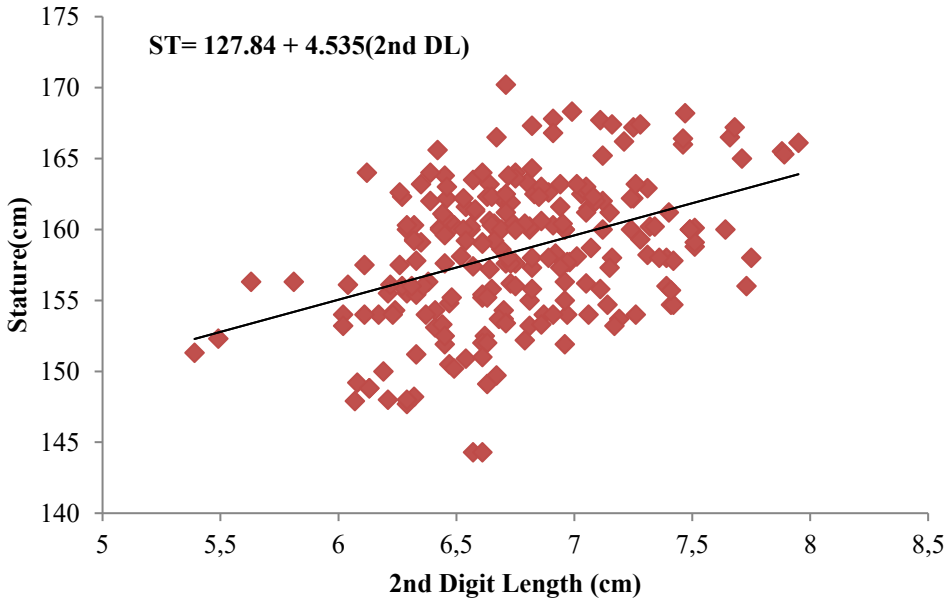

Figure 6: Female regression line of stature on index finger (2nd digit) length.

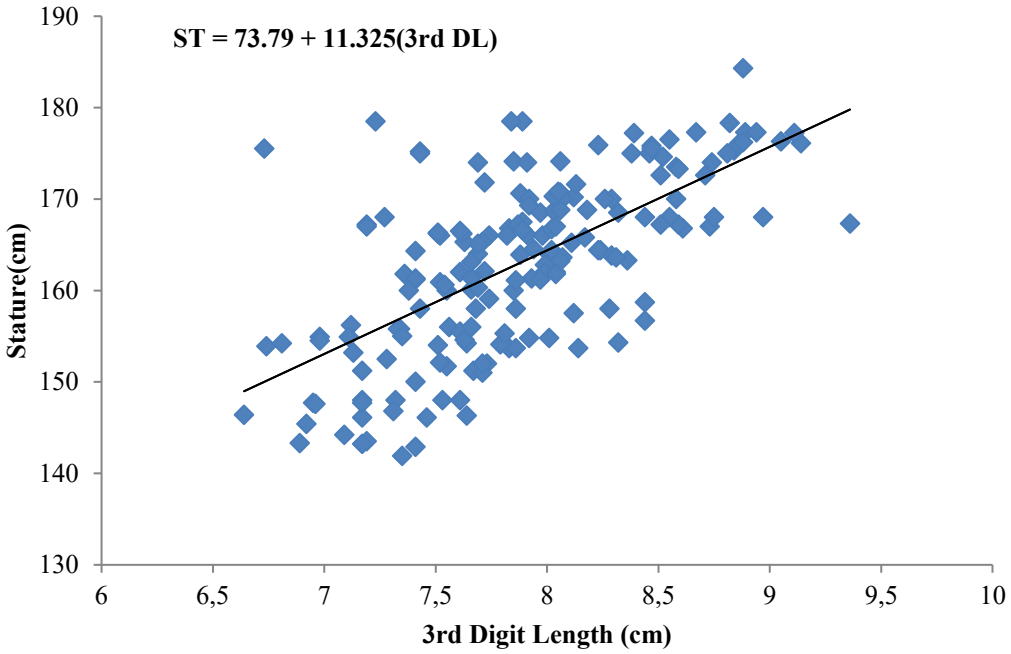

Figure 7: Male regression line of stature on the middle finger (3rd digit) length.

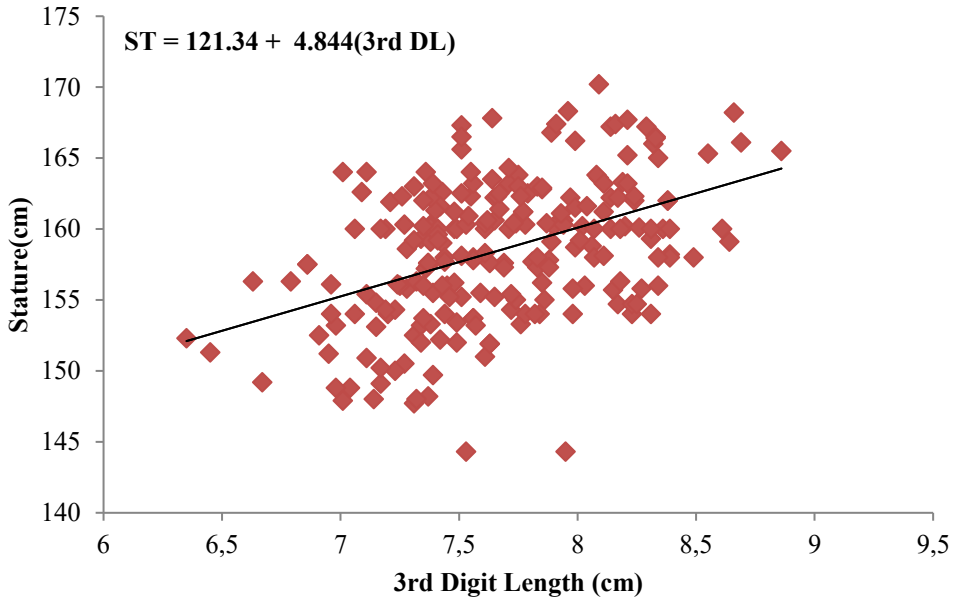

Figure 8: Female regression line of stature on the middle finger (3rd digit) length.

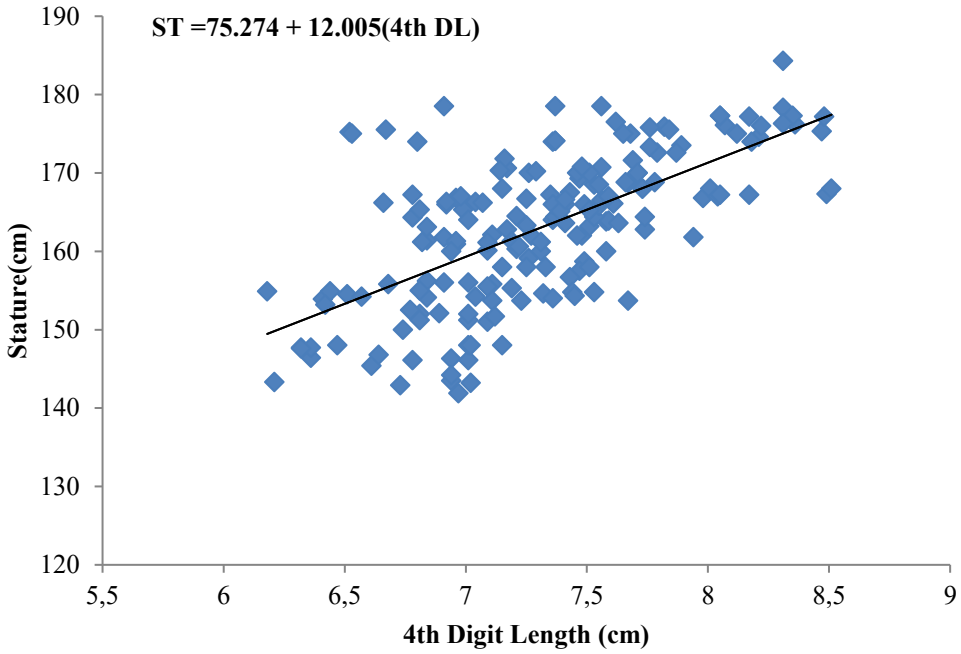

Figure 9: Male regression line of stature on ring finger (4th digit) length.

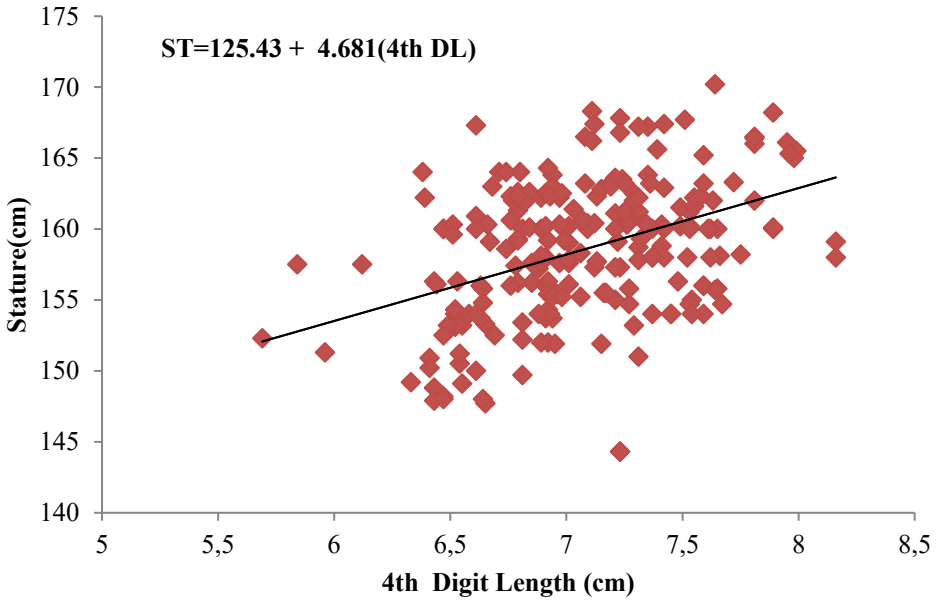

Figure 10: Female regression line of stature on ring finger (4th digit) length.

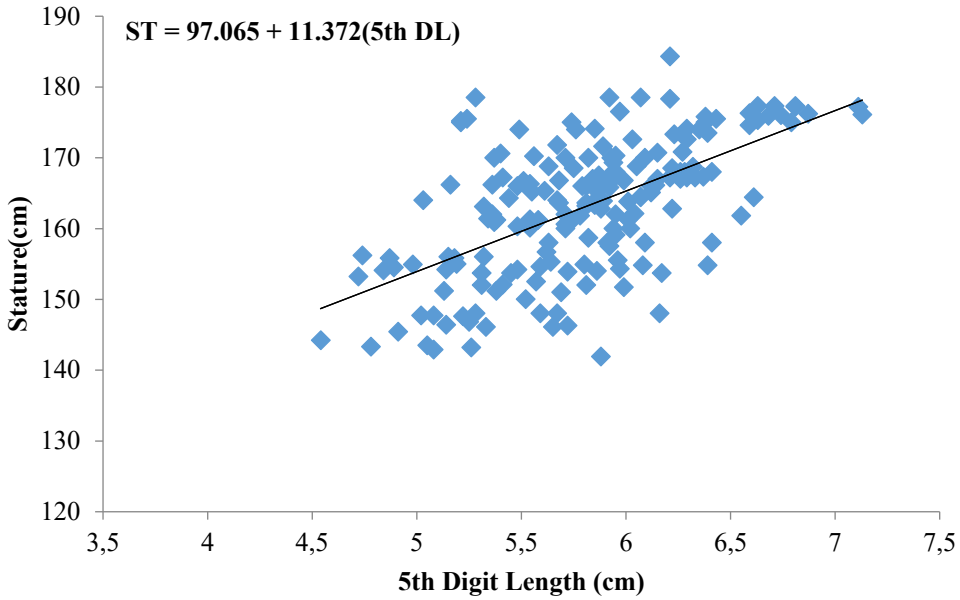

Figure 11. Male regression line of stature on little finger (5th digit) length.

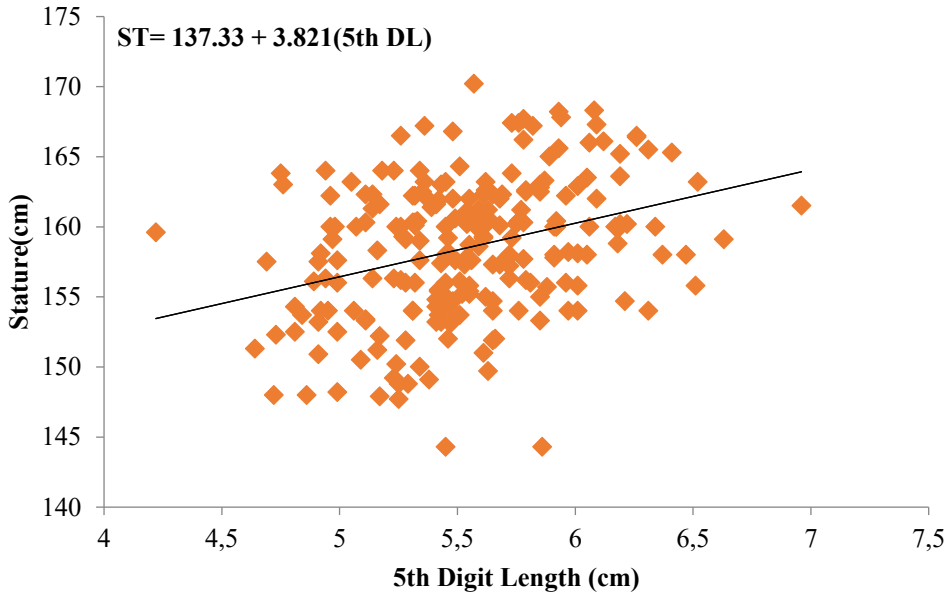

Figure 12. Female regression line of stature on little finger (5th digit) length

The linear regression equations derived from the measured anthropometric parameters (hand length, palm length, lengths of the second, third, fourth and fifth digits) of both male and female participants were checked for accuracy by comparing the calculated stature with the actual stature using the statistical formulae (Imrahan *et al.,* 1993).

$$Accuracy\ rate = \frac{calculated\ stature}{actual\ stature} \times 100\ \%$$

Therefore, value >95% is considered significant.

Table 5: Shows the accuracy rate (percentage) of the linear regression equations of the measured anthropometric parameters of randomly selected male participants (n=30).

Actual Stature				**Calculated Stature**			
S/N	ST	HL	PL	2nd DL	3rd DL	4th DL	5th DL
1	166	159	159	158	159	160	164
2	167	164	163	166	162	159	162
3	160	164	165	157	161	160	160
4	176	170	169	170	167	169	173
5	173	174	171	172	170	169	169
6	163	168	167	166	165	168	168
7	167	167	161	170	171	171	165
8	171	170	173	160	163	161	158
9	176	157	164	157	150	155	157
10	154	159	158	159	160	160	159
11	167	174	171	168	171	173	169
12	176	173	165	179	177	172	178
13	162	162	161	163	161	161	166
14	184	175	170	176	174	175	168
15	168	166	166	166	163	164	164
16	161	163	164	156	161	157	158
17	154	173	170	170	170	174	172
18	175	170	171	160	164	161	164
19	163	171	171	167	166	165	164
20	158	169	168	164	166	169	166
21	169	169	164	169	170	169	170
22	176	167	165	166	167	166	164
23	164	163	163	160	161	157	161
24	165	167	166	167	165	164	164
25	174	164	166	161	160	155	158
26	166	168	166	170	166	167	167

Actual Stature		**Calculated Stature**					
27	154	171	162	172	176	175	172
28	176	162	170	158	151	154	156
29	167	165	167	162	160	166	164
30	169	168	165	170	168	166	168
Average	167	167	166	165	165	165	165
AR %		100 %	99.4 %	98.8 %	98.8 %	98.8 %	98.8 %

ST=stature, HL=hand length, PL=palm length, DL=digit length, AR=accuracy rate.

Table 6: Shows the accuracy rate (percentage) of the linear regression equations of the measured anthropometric parameters of randomly selected female participants (n=30).

Actual stature		**Calculated stature**					
S/N	ST	HL	PL	2nd DL	3rd DL	4th DL	5th DL
1	161	159	158	160	159	160	159
2	160	163	163	161	161	160	161
3	160	160	161	158	159	159	158
4	163	157	157	159	157	157	159
5	160	157	158	157	157	157	158
6	167	164	163	163	162	162	161
7	167	164	165	161	161	159	159
8	160	160	159	158	159	160	159
9	149	157	158	158	156	156	158
10	164	158	158	157	159	158	155
11	162	157	155	158	160	158	158
12	163	156	158	156	156	157	159
13	161	155	152	157	158	157	158
14	154	159	158	158	159	158	158
15	151	152	154	152	153	153	155
16	156	160	158	160	161	161	159
17	158	158	157	159	159	159	159
18	155	155	156	157	156	158	158
19	163	159	159	158	158	159	159

Actual stature		**Calculated stature**					
20	154	156	157	156	156	156	158
21	144	156	155	158	158	159	158
22	160	161	159	162	161	162	159
23	163	160	160	157	159	159	158
24	158	159	156	161	162	162	160
25	166	159	161	157	158	160	160
26	170	164	165	158	161	161	159
27	160	157	157	157	157	157	158
28	168	159	157	160	160	159	161
29	160	159	160	158	159	160	159
30	163	161	161	160	159	159	160
Average	160	159	159	158	159	159	159
AR %		99.4 %	99.4 %	98.8 %	99.4 %	99.4 %	99.4 %

ST=stature, HL=hand length, PL=palm length, DL=digit length, AR=accuracy rate.

DISCUSSION

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 mutilated remains of an unknown person are recovered (Ozaslan *et al.,* 2012). Many studies have been conducted to estimate stature by taking measurements of long bones. So, in spite of the fact that hand dimensions have been previously used for stature estimation in other studies. In this study, it has been assessed among some Fulani adolescents living in Yola for the first time to develop population based equations for stature estimation.

In this study, an independent t- test shows that there was a significant difference in the stature and hand dimensions measured between the two sexes. Previous studies have shown that various hand measurements tend to differ in various races, ethnic groups and also found to be sexually dimorphic (Ebite *et al.,* 2008, Ibegbu *et al.,* 2012, Rajesh *et al.,* 2013, Sanli *et al.,* 2005, Verghese *et al.,* 2010). The result of this study shows that male participants show higher mean value of all the hand parameters measured which indicate that the male participants have significantly larger hands compared to their female counterparts which is in agreement with the works of many researchers who observed that

stature was larger in males compared to females (Badukar & Nath, 1990, Chumlea *et al.,* 1998, Jurmaine *et al.,* 2013, Subashri & Thenmozhi, 2016). It also agrees with studies conducted by Banik *et al.,* 2012, Lewis, 1977, Nihal, 2014, and Rajesh *et al.,* 2013, which revealed that the males mean values for stature are significantly higher than that of the females and the hand dimensions were found significantly higher in males than females. The difference in hand dimension between male and female could be explained as part of genetic expression of male being larger than female. It has also been emphasized that the variations in stature and dimensions of the hand according age, sex and population could also be explained as due to differences in geographical location, nutrition and levels of physical activities of the body and their relation to stature and the dimensions of the hand (Lukpata *et al.,* 2015, Williams *et al.,* 2000).

As regards dimensions in this study, it was observed that stature significantly correlated with all the parameters in both sexes and it was found that the hand length has the highest correlation to stature which indicate that the hand length will give a better estimation of stature than any of the measured parameters in all the participants. This is in agreement with the studies conducted by Barker & Schever, 1998 and Modibbo *et al.,* 2012, they found that, the high degree of correlation was found in hand length, also another study done by Ibegbu *et al.,* 2012, also indicate a significant correlation between stature and hand length, but in a study conducted by Menezes *et al.,* 2009, to estimate the stature of Hausa Neonates from foot and hand dimensions, their results explained that hand breadth was the best predictor of stature among the hand dimensions. The fifth digit length (little finger) shows the least correlation to stature in all the participants measured in this study, but a study conducted by Patel *et al.,* 2012, revealed that there is a significant correlation between the stature and fifth digit length (little finger). However, many studies have shown that stature correlation with hand dimensions vary in different races and this may be attributed to biological and environmental factors.

Linear regression equations were derived to estimate stature when a single dimension is available from the extremities. The reliability of stature estimation using regression equation is revealed by standard error of estimate (SEE) which predicts the deviation of estimated stature from actual stature and is considered as a measure of the accuracy of the equations. In this study, the standard error of estimate (SEE) obtained was higher than that reported previously by Ozaslan *et al.,* 2003, who studied the predictive role of hand and foot dimensions in stature estimation in Turkey. It was also higher than that

achieved by Eveleth & Tanner, 1990, who set models for stature estimation using the hand and phalange lengths in Egyptians. These variations could be explained as a result of genetic and environmental differences. Regression line graphs and accuracy rates were also applied to determine the stature estimation accuracy of each equation. Therefore, it is evident from the study that measurements taken from hand dimensions can be used to predict stature both in males and females among Fulani population.

CONCLUSION

This study show that sex differences exist among the two sexes where male participants have higher significant mean values of the measured parameters than their female counterparts and stature correlated significantly with all the measured hand dimensions with hand length having the highest correlation value, while fifth digit length had the least correlation value for both sexes. Furthermore, this study concluded that the hand dimensions can be successfully used for estimating stature of Fulani adolescents in Yola using the linear regression equations established in this research work.

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