HEIGHT AND SEX DETERMINATION USING HAND DIMENSIONS AND ITS RELATIONSHIP WITH TRIBE

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INTRODUCTION

Determination of sex is mostly regarded as one of the easiest tasks in forensic anthropometry as the direct observation of the genitalia can suggest a person's sex. However, accurate sexing of an individual becomes very complex in situations where the mutilated or fragmentary remains of an individual are paraded before a forensic scientist for examination (Sahana *et al.*, 2015).

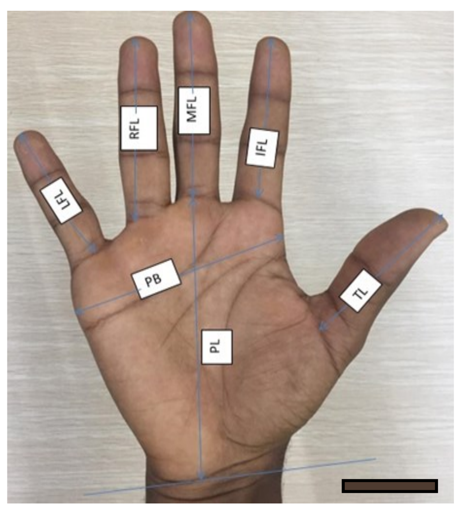
Usually, the vertical growth in the height of an individual comes about as a result of an elongation of the long bones due to endochondral ossification. The dimensional relationship that exists between body parts allows the determination of a person's height which can be widely employed in the identification of an individual in cases of unfortunate incidences (Heinz *et al.*, 2003). Regression models generated for height estimation is population specific (Mendonca, 2000). The surge in international travels as well as unpredictable natural and man-made disasters presents a daunting task of identifying victims from body parts without the benefit of a manifest or record of the possible victim (Aboagye *et al.*, 2014). Analysis of the DNA of possible victims can prove very effective but the utility of such analysis is limited due to technological constraints and economic and financial issues (Mendonca, 2000). Hand dimensions as revealed by several studies differ from population to population and as such there is the need for a preliminary population specific database for hand dimensions to be generated for the estimation of the height of the Ghanaian populace.

The specific objectives were;

- To measure the heights of the participants.
- To determine the mean hand dimensions and finger length and the association with the selected tribes.
- To determine the relationship between height, digit length, sex and tribe.
- To derive a regression model for height from hand dimensions of the participants.

MATERIALS AND METHODS

The present descriptive cross sectional study was conducted at the Anatomy Department, School of Medicine and Dentistry, KNUST, from September 2018 to April 2019. Informed participant consent and ethics approval from the Committee for Human Research and Publications Ethics (CHRPE) were sought prior to the study. Convenient random sampling method was used to recruit 345 participants for the present study. Individuals with physical deformities and systemic illness affecting stature and hand measurements were excluded from the study. The height of the participants was measured in centimetres (cm) using Shahe height meter (Shanghai, China). The parameters of both hands were taken with the Hewlett Packard Scanjet 300 flatbed photo scanner (China) and the Coral draw X7 software was used to measure the various hand parameters (Figure 1). Also, the sex, age and tribe of each participant were recorded. All measurements were taken and recorded by the same person to minimize sampling errors and to ensure reproducibility. All the measurements were taken at a fixed time of the day to eliminate diurnal variations. Data analysis was carried out using SPSS version 20.0.



TL= Thumb length, IFL=Index Finger Length, MFL=Middle Finger Length, RFL=Ring Finger Length, LFL=Little Finger Length, PB= Palm Breadth, PL=Palm Length

Figure 1: An illustration of how the hand parameters were measured using Coral draw X7 (X 0.2).

RESULTS AND DISCUSSION

SAMPLE STATISTICS

A total of 345 participants were recruited for the present study. Out of the total participants, 281 (81.4 %) belonged to the Akan tribe, 11 (3.2 %) belonged to Ga-Adangbe, 21 (6.1 %) belonged to the Ewe tribe and the remaining 32 (9.3 %) belonged to other tribes (Nzema, Frafra, Dagaati, Dagomba, Mamprusi, Ahanta, Sisaala).

HEIGHT OF THE PARTICIPANTS

Comparatively, the male participants in the study were taller than the female participants (Table 1). Sexual dimorphism in height largely comes about as a result of the sex hormones which regulate the activities of sex specific characteristics. Furthermore, this height disparity can be linked to the fact that there is early skeletal maturity in females compared to males, which gives males an extra two years of growth, also females tend to have early growth cessation unlike males (Krishan and Sharma, 2007). This is consistent with studies by Oria *et al.*, (2016); Lima *et al.*, (2018) and Ibrahim *et al.*, (2018).

TABLE 1: DISTRIBUTION OF HEIGHTS AMONG THE PARTICIPANTS

Index	Sex	N	Mean ± SD (cm)	Range (cm)	p value
Height	M	203	171.48 ± 6.56	156.10 – 192.50	0.000**
	F	142	161.91 ± 6.35	145.90 – 180.60	
	Total	345	167.56 ± 7.99	145.90 – 192.50	

*SD = Standard Deviation, cm =centimetres, F = Female, M = Male, N = Number of participants, p—value = probability value, ** = statistically significant*

HAND AND HEIGHT MEASUREMENTS AMONG THE TRIBES

Ewe males were significantly taller than all the other tribes followed by Akan males then the males of the "other tribes". Females belonging to the "other tribes" recorded the highest mean value for height followed by Akan females and then Ewe females. Ga-Adangbe females were the shortest. The mean heights of the tribes studied varies numerically but the difference was not statistically significant.

There was no difference in the means of all the hand parameters amongst both sexes in the various tribes used in the study. Participants from the "other tribes" recorded the highest mean value for all the right hand parameters except the right palm length. Ewes recorded the highest mean value for the right palm length. The "other tribes" recorded the highest mean values for all the left hand parameters except the left ring finger. Ewes recorded the highest mean for the left ring finger.

CORRELATION BETWEEN HEIGHT AND HAND DIMENSIONS

All the parameters of the hand dimensions showed a statistically significant difference ($p < 0.05$). Among the males, right middle finger length showed the strongest correlation with height ($r = 0.403$) with the right palm breadth exhibiting the weakest correlation with height ($r = 0.189$). Considering the females, right hand length showed the highest correlation ($r = 0.375$) and right palm breath recorded the least correlational co-efficient of 0.185.

The correlation analysis indicated a highly statistically significant association between height and all the left hand parameters ($p < 0.05$) in both males and females with the exception of the left palm breadth in females. Left middle finger length and left hand length were the indices that existed the highest correlation with height in males ($r = 0.371$) and females ($r = 0.398$) respectively. This was consistent with a study by Kanchan and Rastogi, (2009).

REGRESSION MODELS FOR HEIGHT ESTIMATION USING HAND MEASUREMENTS

The regression equation was done for the left hand parameters which showed a moderate relationship with height ($p < 0.05$). A hypothetical regression equation was used to estimate height from the hand parameters in both males and females as shown as follows: $Y = MX + C$ (where X = measured hand dimension, Y = estimated height, C = constant, M = regression coefficient). There was no bilateral difference between the thumb, middle and index finger of the left and right hands. In view of that, single regression models were derived for them using the left hand indices (Table 2).

TABLE 2 : DERIVATION OF REGRESSION EQUATIONS FOR HEIGHT ESTIMATION USING LEFT HAND DIMENSIONS STRATIFIED BY SEX.

Parameter	Sex	Regression Equation	Adjusted R^2	SEE
LIFL	M	H = 4.731 (LIFL)+136.263	0.116	6.17
	F	H = 5.012 (LIFL)+126.274	0.151	5.85
LMFL	M	H = 4.435 (LMFL)+134.075	0.133	6.11
	F	H = 3.964 (LMFL)+130.018	0.118	5.96
LLFL	M	H = 3.631 (LLFL)+148.726	0.067	6.34
	F	H = 4.351 (LLFL) +135.956	0.107	6.00
LHL	M	H = 2.269 (LHL)+ 126.468	0.131	6.12
	F	H = 2.157 (LHL) +121.340	0.153	5.84
LPL	M	H =3.075 (LPL) +136.404	0.087	6.27
	F	H =3.460 (LPL) +124.638	0.144	5.87
LTL	F	H = 4.483 (LTL) + 133.222	0.104	6.00
	M	H = 3.291 (LTL) + 149.370	0.055	6.38
LPB	M	H = 2.575 (LPB) + 148.687	0.035	6.45
	F	H = 2.022 (LPB) + 1144.916	0.016	6.29
LRFL	F	H = 4.282 (LRFL) + 129.648	0.136	5.89
	M	H = 4.343 (LRFL) + 137.274	0.123	6.14

LPB =Left Palm Breadth; LPL = Left Palm Length; LHL = Left Hand Length; LLFL = Left Little Finger Length; LRFL = Left Ring Finger Length; LMFL = Left Middle Finger Length; LIFL = Left Index Finger Length; LTL = Left Thumb Length; p-value = probability value; H = Height; M = Male; F = Female; SEE = Standard Error of Estimation; R^2 = coefficient of determination

Like the measured left hand dimensions, regression equation was derived for the right hand parameters which also showed a moderate correlation with height ($p < 0.05$). A hypothetical regression equation was used to estimate height from the hand parameters in both males and females as shown as follows: $Y = MX + C$ (where M = independent variable, C = constant, X = regression coefficient) (Table 3).

TABLE 3: REGRESSION MODEL FOR HEIGHT ESTIMATION USING THE RIGHT HAND DIMENSIONS BASED ON SEX.

Parameter	Sex	Regression Equation	Adjusted R^2	SEE
RIFL	M	H=4.730 (RIFL)+136.422	0.114	6.18
	F	H =5.850 (RIFL)+124.336	0.139	5.91
RRFL	M	H =4.526 (RRFL) +135.968	0.129	6.13
	F	H =4.204 (RRFL) +130.209	0.116	6.00
RHL	M	H =2.567 (RHL) + 120.770	0.152	6.04
	F	H =2.140 (RHL) +121.789	0.134	5.90
RPL	M	H =3.186 (RPL) +135.318	0.083	6.28
	F	H =3.083 (RPL) +128.848	0.105	6.00
RPB	M	H =2.372 (RPB) + 150.352	0.031	6.48
	F	H =2.420 (RPB) + 141.493	0.027	6.26

RPB =Right Palm Breadth; RPL = Right Palm Length; RHL = Right Hand Length; RLFL = Right Little Finger Length; RRFL = Right Ring Finger Length; RMFL = Right Middle Finger Length; RIFL = Right Index Finger Length; RTL = Right Thumb Length; H = Height; M= Male; F = Female;, SEE = Standard Error of Estimation; R^2 = coefficient of determination

SEX DETERMINATION USING HAND DIMENSIONS

Stepwise binary logistics was used in the determination of a better predictor of sex using the measured hand dimensions. Two models for sex were formulated to reliably predict sex with different percentage accuracies. The first model utilized the right palm length in the prediction of males with a percentage accuracy of 82.3% and 54.2% for females. The overall percentage accuracy was 70.7%. The second model utilized the right palm length and the right palm breadth and accurately predicted 79.8% males and 56.3% females with an overall percentage accuracy of 70.1%. Y (independent variable) is male when the result of the equation is $0 \leq \log(Y) \leq 0.5$ whereas Y (independent variable) is female when the result of the equation is $0.51 \leq \log(Y) \leq 1$ (Table 4). The study was consistent with the present study. Kanchan and Rastogi, (2009) stated in their study that the right palm breadth is the best predictor of sex amongst North and South Indians.

TABLE 4: REGRESSION EQUATIONS FOR THE DETERMINATION OF SEX USING THE HAND DIMENSIONS.

Parameter	Regression Equation	R^2
RPL	Log (Y) = -1.485 (RPL) + 16.05	0.243
RPL, RPB	Log (Y) = -1.025 (RPL) -1.018(RPB) + 19.814	0.282

R^2 = coefficient of determination; RPL = Right Palm Length; RPB = Right Palm Breadth.

CONCLUSION

In the present study, males were significantly taller than females. Also, males recorded higher mean values for all the measured hand parameters than their female counterparts and the difference was statistically significant. No significant variation was observed between the measured hand dimensions of the studied tribes. The right palm length and the right palm breadth were the best predictors of sex. Right middle finger was the best marker for height estimation among the males and the left hand length was the best index for height estimation among the females.

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