ANTHROPOMETRIC STUDY OF HEIGHT AND SEX USING ARM SPAN AND ITS ASSSOCIATION WITH TRIBE

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INTRODUCTION

Anthropometry remains a valuable tool in various fields of science particularly, forensics (WHO, 1995). The structure of the human body varies from person to person and serves the basis for the identification of individuals in the field of forensic science (Bhavna and Nath, 2009; Shah *et al.*, 2013).

The height of an individual is an inherent character and is considered as one of the important parameters for personal identification (Bhavna and Nath, 2009). Extensive research has been carried out on stature determination using body parts such as hand prints, arm span, limbs and footprints in different populations. Arm span measurement has been established to have a strong correlation with height and can serve as a reliable index for height estimation (Mononai *et al.*, 2010). Sex is another valuable index in the identification of persons. It takes precedence over height estimation and remains the first step in classifying individuals (Shah *et al.,* 2013).

In the developed countries, there are well established data on height and sex determination using arm span measurement; however, there appears to be limited investigations done on the use of arm span to determine the sex and height of an individual. Moreover, the generation of regression models for height estimation by considering inter-ethnic variation appears to be scanty in Ghana and most developing countries. Therefore, the present study aimed to establish a database for height and sex determination using arm span and it association with tribe among Ghanaians. The specific objectives were;

- To measure the height and arm span of both male and female participants.
- To compare height and arm span measurement among the various tribes used in the study.
- To determine the correlation between height and arm span length.
- To derive regression models for the determination of height and sex using arm span measurement of participants

MATERIALS AND METHODS

The present study was conducted at the Anatomy Department, School of Medicine and Dentistry, KNUST, from September 2018 to May 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 297 participants for the present study; 182 (61.3%) males and 115 (38.7%) females between the ages of 16 - 34 years. Individuals without any apparent form of skeletal or physical disabilities and without history of skeletal injuries or diseases affecting the bones and joints were recruited for the study. Participants with spinal or limb deformities, physical signs of endocrine disorders such as dwarfism or gigantism, inability to stand or difficulty in extending arms were excluded from the study. The height of participants was measured with a Shahe's Stature Meter (Shanghai, China) and their arm span with a Dritz C150 fiber glass measuring tape (Prym consumer USA Inc) (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.

Figure 1 : A photograph showing the measurement of arm span (×0.3)

DATA ANALYSIS

The data collected was coded using Microsoft excel 2013 and analysed using SPPS version 20.0. Regression analysis of arm span to generate an equation to determine height and sex was done. Normal limits were defined by regression with a 95% confidence interval.

RESULTS AND DISCUSSION

SAMPLE CHARACTERISTICS

The total number of 297 participants including 182 (61.3%) males and 115 (38.7%) females were recruited for the present study. Out of the 297 participants considered for the study, 237 (79.8%) belonged to the Akan tribe, 15 (5.1%) were Ga-Adangbes, 16 (5.4%) were Ewes, and the remaining 29 (9.8%) belonged to other tribes. The age range of the participants was between 16 - 34 years with the mean age being 19.73 ± 2.06 years.

HEIGHT MEASUREMENT AMONG MALES AND FEMALES

Males were significantly taller than females in the present study ($p < 0.01$) (Table 1). This result was consistent with a research work by Mohammed *et al.* (2013) among Malaysian population. Banik (2011) also observed that, males were significantly taller than females among Egyptian population and attributed the difference to the varying effects of sex hormones in both males and females.

Table 1: Height measurement stratified by sex

	Sex	N	Mean ± SD (cm)	Range (cm)	p - value
HEIGHT	Male	182	171.38 ± 6.79	156 - 193	0.000
	Female	115	162.60 ± 6.68	146 - 181	

N=*Number of participants;* ***SD.*** *= Standard Deviation;* ***cm*** *= centimeters;* ***p-value*** *= Probability value.*

COMPARISON OF HEIGHT MEASUREMENT AMONG THE TRIBES

Among the tribes, Akans recorded the highest mean height of 168 ± 8.30 cm with Ga-Adangbes having the least mean height of 167.15 ± 8.03 cm. However, the difference in mean height among the various tribes was not statistically significant ($p = 0.919$) (Table 2).

Table 2: Height measurement stratified by tribe

Parameter	Tribe	N	Mean ± SD (cm)	Range (cm)	p-Value
HEIGHT	Akan	237	168.14 ± 8.30	146-193	0.919
	Ga-Adangbe	15	167.15 ± 8.023	152-181	
	Ewe	16	167.26 ± 6.42	156-182	
	Others	29	167.48 ± 6.12	159-179	
	Total	297	167.98 ± 7.98	146-193	

N=*Number of participants;* ***SD.*** *= Standard Deviation;* ***cm*** *= centimeters;* ***p-value*** *= Probability Value.*

ARM SPAN MEASUREMENT AMONG MALES AND FEMALES

The mean arm span for both males and females were 180.51 ± 9.09 cm (range: 126 to 200 cm) and 162.31 ± 8.85 cm (range: 149 to 194 cm) respectively and the difference was statistically significant ($p < 0.001$) (Table 3). The findings of this study were in accordance with a study by Banik (2011) who also observed significant difference between the arm span of Indian males and females. Also, Lin *et al.* (2001) reported that, there are differences in the level of insulin-like growth factor-1(IGF-1) levels among males and females and this could be a contributing factor to the variation observed.

Table 3: Arm span measurement stratified by sex

	Sex	N	Mean ± SD (cm)	Range (cm)	p - value
ARM SPAN	MALE	182	180.51 ± 9.09	126-200	0.000
	FEMALE	115	169.78 ± 8.85	149-194	

N=*Number of participants;* ***SD****= Standard Deviation;* ***cm*** *= centimeters;* ***p-value*** *= Probability value.*

ARM SPAN MEASUREMENTS AMONG THE TRIBES

The mean arm span recorded for Akans, Ewes, Ga Adangbes and other tribes were 176.41 ± 10.71 cm, 174.27 ± 11.01 cm, 175.25 ± 7.83 cm and 177.62 ± 8.88 cm respectively. Individuals from other tribes recorded the highest mean arm span with the Ga- Adangbes recording the lowest mean arm span value. The differences in mean arm span measurements for the various tribes used in this present study was not statistically significant ($p = 0.705$) (Table 4).

Table 4: arm span measurement among the tribes

Parameter	Tribe	N	Mean ± SD (cm)	Range (cm)	p-Value
ARM SPAN	Akan	237	176.41 ± 10.71	126-200	0.705
	Ga-Adangbe	15	174.27 ± 11.02	152-190	
	Ewe	16	175.25 ± 7.84	158-185	
	Others	29	177.62 ± 8.88	162-197	
	Total	297	176.36 ± 10.40	126-200	

N=*Number of participants;* ***SD****= Standard Deviation;* ***cm=*** *centimeters;* ***p-value=*** *Probability value*

CORRELATION BETWEEN HEIGHT AND ARM SPAN MEASUREMENTS

There was a statistically significant positive correlation between height and arm span measurements in both males ($r = 0.649$, $p < 0.001$) and females ($r = 0.703$, $p < 0.001$) but that of females exhibited a stronger correlation than males. This observation is consistent to those obtained from a similar study conducted by Banik (2011) in India.

HEIGHT ESTIMATION USING ARM SPAN MEASUREMENT

A simple linear regression was carried out to determine a model to predict height using arm span. Considering the sex specific regression model, the formulae derived for the male participants could predict the height of about 41.8% of the male population (adj $R^2 = 0.418$) and for females, could predict the height of about 48.9% of the female population (adj $R^2 = 0.489$)(Table 5). Therefore, arm span was a better predictor of height among the females than the males in the present study. This was in line with reports by Ter *et al.* (2003) and Banik (2011).

Table 5: Linear Regression equation for height estimation using arm span

Sex	Regression equation	SEE	R	R^2	AdjR^2
Male	0.484 x AS + 83.953	5.179	0.649	0.421	0.418
Female	0.530 x AS +72.540	4.775	0.703	0.494	0.489

SEE *= Standard error of estimate;* ***R*** *= correlation coefficient;* ***R^2*** *= coefficient of determination;* ***AdjR^2*** *= Adjusted coefficient of determination;* ***AS*** *= arm span measurement*

DETERMINATION OF SEX USING ARM SPAN MEASUREMENT

Binary logistic regression model was employed to derive model for sex determination using arm span with an overall prediction accuracy of 77.8% (Table 6). This was consisted with a study by Aye (2010) who concluded that, arm span is sexually dimorphic.

Table 6: Binary logistic regression for sex determination using arm span

	B	S.E.	Wald	p-value	R^2
ARMSPAN	-0.139	0.018	56.700	0.000	0.348
Constant	23.949	3.233	54.880	0.000	

B = *Beta coefficient;* ***Wald =*** *Wald statistic;* ***p-value =*** *probability value;* ***S.E. =****Standard error;* ***R^2 =*** *Coefficient of determination; Male = 1; Female = 0; cut off point = 0.5*

CONCLUSION

Male participants were significantly taller than females. Males also had a significantly longer arm span than females. Both Height and arm span measurements showed no significant variation among the various tribes used in the present study. A strong correlation between height and arm span measurements among males and females was also observed. Arm span was a useful model for height and sex determination in the present study.

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