RELATIONSHIP BETWEEN MID-UPPER ARM CIRCUMFERENCE, HEIGHT AND TOTAL FACIAL HEIGHT

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INTRODUCTION

Estimation of height is an indispensable tool in forensic examination especially in the identification of unknown, highly decomposed and mutilated body parts (Krishan, 2008). Height measurement is also essential for the assessment of children's growth and calculation of their nutritional indices. It is also used in the calculation and standardization of physiological parameters such as lung volumes, muscle strength, glomerular filtration, basal metabolic rate and essential for adjustment of drug dosage in patients (WHO, 1995). Estimation of height from various body parts such as ulnar length, radial length, femoral measurements and dimensions of hands and feet have been documented in a number of studies (Hauser *et al*., 2005; Ozaslan *et al*., 2006; Krishan and Sharma *et al*., 2007). However, this is not feasible when only the skull is available for identification purposes. Analyses of cephalo-facial dimensions are considered one of the most promising means for personal identification. The face has been found to be correlated with body height (Krishan and Kumar, 2007; Ryan and Bidmos, 2007; Krishan, 2008; Sahni *et al*., 2010). The total facial height and mid-upper arm circumference have been proven in various studies to correlate with height (Krishan, 2007; Nurcan, 2009; Sahni, 2010). In the developed countries, the facial dimensions and mid upper arm circumference have been used to generate regression formulae for determining height. These formulae are population specific, therefore it is not suitable to use these derived formulae for determining height in the Ghanaian population. There is therefore the need to develop regression models using the mid upper arm circumference and total facial height of Ghanaian individuals which would be suitable in height determination and also provide a preliminary baseline data in the Ghanaian population.

The specific objectives were;

- To determine the height of the male and female participants.
- To determine the mid-upper arm circumference of the male and female participants.
- To determine the total facial height of the male and female participants.
- To determine the correlation between mid-upper arm circumference, height and total facial height.
- To derive a regression model for estimation of height using mid upper arm circumference and total facial height.

MATERIALS AND METHODS

The present 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 306 participants. They included 183 males and 123 females between the ages of 16 to 34 years. Healthy participants with no facial, vertebral column and limbs deformities were included in the study. Participants who did not give their consent were excluded. The height of the participants were taking using Shahe's height meter (Shanghai, China). Total facial height was taken using Shahe's vernier caliper (Shanghai, China) (Figure 1). Mid-upper arm circumference was taken using fibre glass measuring tape. All measurements were taken and recorded by the same person to minimize sampling errors and to ensure reproducibility.

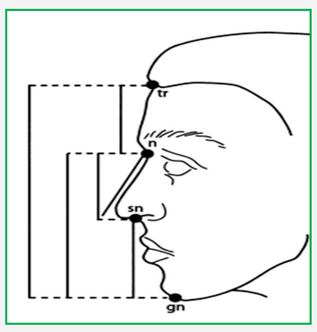

Figure 1: Measurements on the lateral aspect of the face .

*Head: **tr-n** (forehead height) Face: **tr-gn** (physiognomical face height) **n-gn** (total facial height height) **sn-gn** (lower face height) Nose: **n-sn** (nose height) (Farkas et al., 2005).*

DATA ANALYSIS

The data collected was coded using Microsoft excel 2013 and analysed using SPPS version 20.0. Descriptive statistics was performed to ascertain the mean, standard deviation and the range of the measured height, total facial height and mid-upper arm circumference of the participants. Regression equations were derived for the prediction of height from total facial height and mid-upper arm circumference. A probability value less than 0.05 was considered statistically significant (confidence interval of 95%).

RESULTS AND DISCUSSION

Descriptive statistics for age and anthropometric parameters of study group.

A total of 306 participants were recruited for the study. They included 59.8% (183) males and 123% (40.2%) females between the ages of 16 years to 34 years. The mean age recorded for males and females were 19.98 ± 2.17 years and 18.96 ±1.35 years respectively. Males were taller and had wider total facial height than females and the difference was statistically significant. However, females recorded numerically narrower mid-upper arm circumference for both right and left arms than the male participants, the difference was not statistically significant (p > 0.05) (Table 1). This is consistent with studies done by Sahni *et al*. (2010), Farkas *et al*. (2005) and Liu *et al*. (2018).

Table 1: Comparison of the anthropometric indices of the study population using independent t-test

Measurements (cm)	Mean ± SD (Males)	Mean ± SD (Females)	p-value	T-test
Height	171.96 ± 6.81	161.97 ± 3.89	<0.001*	12.41
LMUAC	27.46 ± 3.17	27.37 ± 3.89	0.824	0.223
RMUAC	27.68 ± 3.17	27.66 ± 4.05	0.968	0.40
TFH	11.70 ± 0.70	11.06 ± 1.64	<0.001*	8.20

***LMUAC**=Left mid-upper arm circumference, **RMUAC**=Right mid-upper arm circumference, **TFH**=Total facial height, **p**= probability, * = Statistically Significant Difference (p < 0.05), **cm =** Centimetre*

Bilateral symmetry of mid-upper arm circumference

Mean right mid-upper arm circumference was observed to be numerically higher than mean left mid-upper arm circumference of the study population, the difference was not statistically significant (p = 0.084) (Table 2). This symmetrical pattern observed in the present study was consistent with Liu *et al*. (2018).

Table 2: Bilateral differences of the mid-upper arm circumference

	Mean ± SD	p-value
LMUAC (cm)	27.432 ± 3.46	0.084
RMUAC (cm)	28.002 ± 6.53	

***LMUAC**=Left mid-upper arm circumference, **RMUAC**=Right mid-upper arm circumference, **p**= probability, * = Statistically Significant Difference (p < 0.05), **cm =** Centimetre*

Correlation between measured parameters and height of the general population

From Table 3, right and left mid-upper arm circumference exhibited a positive weak significant correlation with height (rRMUAC = 0.119, rLMUAC = 0.118). Total facial height on the other hand showed a positive moderate correlation with height and it was statistically significant (p < 0.001). This indicated that, total facial height was a better index for estimation among the study population as compared to right and left mid-upper arm circumference. This was consistent with studies conducted by Krishan (2007), Krishan and Kumar (2008) and Nurcan *et al*. (2009).

Table 3: Correlation between parameters measured.

	r	p-value
Height and LMUAC	0.118*	0.039
Height and RMUAC	0.119*	0.038
Height and TFH	0.448*	<0.001

***LMUAC**=Left mid-upper arm circumference, **RMUAC**=Right mid-upper arm circumference, **p**= probability, * = Statistically Significant Difference (p < 0.05), **r** = Pearson's correlation co-efficient*

Correlation between measured parameters stratified by sex

Among the males, both right and left MUAC weakly correlated with height and it was statistically significant (rRMUAC = 0.157, p = 0.031 and rLMUAC = 0.157, p < 0.034). Also, total facial height exhibited significant weak correlation with height (r = 0.248, p < 0.001). In addition, both right and left MUAC showed significant weak correlation with total facial height rRMUAC = 0.317, rLMUAC = 0.310) (Table 4).

Like the males, MUAC (right and left) of the females had a weak correlation with total facial height (RMUAC; r = 0.178, p = 0.048) and LMUAC; r = 0.152, p = 0.093). Height weakly correlated with MUAC (right and left) but it was not significant. The correlation between height and total facial height was also weak and statistically significant (r = 0.317, p < 0.001) (Table 4). This was in agreement with studies by Krishan (2008), Nurcan *et al*. (2009) and Sahni *et al*. (2010).

Table 4: Pearson correlation between measured parameters of males and females

	MALES		FEMALES	
	r	p-value	r	p-value
Height and LMUAC	0.157*	0.034	0.112	0.217
Height and RMUAC	0.157*	0.031	0.130	0.151
Height and TFH	0.248*	0.001	0.317*	<0.001
LMUAC and TFH	0.310*	<0.001	0.152	0.093
RMUAC and TFH	0.317*	<0.001	0.178*	0.048

***LMUAC**=Left mid-upper arm circumference, **RMUAC**=Right mid-upper arm circumference, **TFH**=Total facial height, **p**= probability, * = Statistically Significant Difference (p < 0.05), **r** = Pearson's correlation co-efficient*

HEIGHT ESTIMATION USING TOTAL FACIAL HEIGHT

Linear regression equation was derived for total facial height (TFH) as a model for height estimation since it was the only index that exhibited a moderate correlation with height. It was able to correctly predict 14.9% of the overall study population with standard error of estimation (SEE) of 7.446. (Table 5).

This was consistent with Agnithori *et al.* (2011) who found out that accurate estimation of stature using total facial height was possible in the Mauritian population.

Table 5: linear regression analysis for height estimation using total facial height

Variables	Linear regression equation (H) =a + bX	SEE	Adj R^2
TFH (cm)	H = 126.820+ 3.613(TFH)	7.669	0.149

***TFH**=Total facial height, **S.E.E.=** Standard error of estimate, **Adj R^2** = Adjusted Coefficient of determination, **H** = approximated height, **cm =** Centimetre*

CONCLUSION

It has been shown in the present study that, males are significantly taller than females. Also, males have significantly taller total facial height than females. The recorded mid-upper arm circumference showed no sexual dimorphism. Total facial height had a moderate correlation with height and was a better predictor of height as compared to the mid-upper arm circumference. This study has provided preliminary baseline information for the general Ghanaian population and will be useful for biometric and forensic purposes and facial reconstructive surgery.

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