A MORPHOMETRIC STUDY OF DIGIT AND CLAVICULAR LENGTHS IN HEIGHT ESTIMATION

Dason, A. R. M. Y., Abaidoo, C. S. Darko, N. D., Appiah, A. K., Tetteh, J., Diby, T., Okwan, D., Adjei-Antwi, C., Nketiah, J., Robertson, J. and Bempah, S.

Department of Anatomy, School of Medicine and Dentistry, KNUST, Kumasi, Ghana

INTRODUCTION

The height of an individual forms an important part of human identification and profiling (Hisham *et al.*, 2012). Nutrition, ethnicity and race affect height since they are implicated in the growth and development of an individual (Ahuja *et al.*, 2018). The development of the hands begins with the flattening of the distal ends of the extremity buds from the 34th to 38th days of development forming paddle-like hand plates. Subsequently, the development of the digits commences with the fragmentation of apical ectodermal ridges on the 46th day of development, causing hand plates to take a notched shape the formation of digit rays (Singh *et al.*, 2015; Baykal and Turkkan, 2017). Due to the specific pattern of ontogeny and age-related changes of the sternal articular surface of the clavicle during adulthood, it is widely used in the estimation of age at death, and for age estimation in living people (Kreitner *et al.*, 1998; Schulz *et al.*, 2005). Body proportions and the dimensions of various body segments, including the long bones of the limbs and bones of the hand and foot have been used to estimate height (IIayperuma *et al.*, 2009). There appears to be limited data on studies that have used either digit or clavicular lengths to estimate height among the Ghanaian population. Therefore, the study sought to generate data on digit and clavicular lengths and evaluate their relationship with height.

The specific objectives of the present study were;

- To determine the relationship between digit length, clavicular length and height.
- To derive regression models for height estimation using digit and clavicular lengths.

MATERIALS AND METHODS

This 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), School of Medicine and Dentistry were sought prior to the study. Convenient random sampling method was used to recruit 230 participants into the study. This comprised 137 males and 93 females whose ages ranged from 16 to 28 years. Individuals with no hand deformity or scar on the hand (fingers) were recruited into the study. Participants with hand deformities were excluded from the study. Hands of participants were taken using Canoscan LiDE 120 scanner (USA) connected to a computer. The parallel dimension tool of Corel Draw X7 application was used for the measurement of the finger lengths (Figure 1). In the Frankfurt plane, height of the participants was taken using Shahe's Height Meter (Shanghai, China). All measurements were taken and recorded by the same person to minimize sampling errors and to ensure reproducibility.

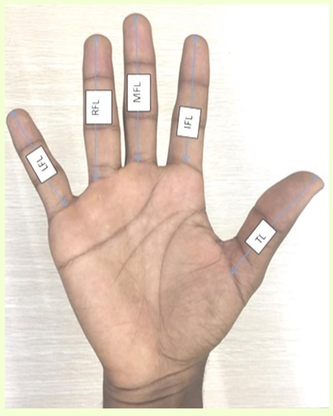

Figure 1: A scanned image showing measurements of the hand digits.
TL= Thumb length, IFL= Index finger length, MFL= Middle finger length, RFL= Ring finger length and LFL= Little finger length

STATISTICAL ANALYSIS

The data were compiled, tabulated and coded on a Microsoft Excel Spreadsheet version 2013. The data collected were then analysed statistically using the programme IBM Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics was performed to determine the means of the measured parameters.

Correlation and regression analysis were performed where necessary. A probability value less than 0.05 was considered statistically significant (confidence interval of 95%).

RESULTS AND DISCUSSION

SAMPLE CHARACTERISTICS

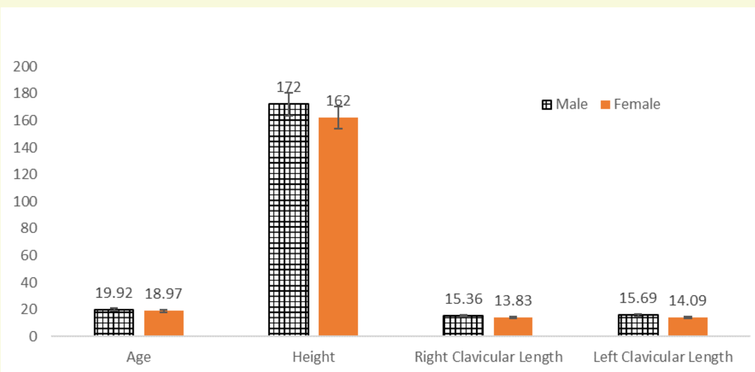

Figure 2: Descriptive analysis of age and measured parametres in relation to sex

A total of 230 participants were recruited into the present study. They comprised 137 males (59.57%) and 93 females (40.43%). The distruibution in terms of age, height and clavicular length is shown in Figure 2. The difference between the male and female mean height was statistically significant ($p < 0.05$). Findings of the present study as regards males being significantly taller than females is consistent with that reported by other investigators (Sen *et al.*, 2014; Oladipo *et al.*, 2015; Zulkifly *et al.*, 2018).

Males recorded significantly longer right and left clavicular lengths than the females. This agrees with a study by Bindhu and Blessina (2015).

DESCRIPTIVE STATISTICS OF LEFT AND RIGHT DIGIT LENGTHS IN MALES AND FEMALES

Like clavicular length, males recorded longer digit lengths for both right and left hands than their female counterparts and the difference was statistically significant (Tables 1 and 2). Findings are in line with reports of several studies (Matheswaran and Ranganath, 2014; Sen *et al.*, 2014; Zulkifly *et al.*, 2018).

Table 1: Descriptive statistics of left digit lengths in both male and female participants

	Sex	Mean ± SD (cm)	Range (cm)	p-value
TL	Male	6.71 ± 0.45	5.33—7.77	0.000
	Female	6.40 ± 0.47	5.11—7.64	
IFL	Male	7.46 ± 0.47	6.08—8.62	0.000
	Female	7.11 ± 0.51	5.77—8.48	
MFL	Male	8.46 ± 0.52	6.78—9.58	0.000
	Female	8.10 ± 0.58	6.72—9.35	
RFL	Male	7.88 ± 0.52	6.19—9.16	0.000
	Female	7.57 ± 0.59	6.12—8.93	
LFL	Male	6.28 ± 0.46	5.09—7.41	0.000
	Female	5.98 ± 0.51	4.61—7.47	

***TL** = Thumb length; **IFL** = Index finger length; **MFL** = Middle finger length; **RFL** = Ring finger length; **LFL** = Little finger length; **SD** = Standard deviation; **cm** =Centimetre; **p-value** = Probability value*

Table 2: Descriptive statistics of right digit lengths in males and females

	Sex	Mean ± SD (cm)	Range (cm)	p-value
TL	Male	6.75 ± 0.44	5.59 —7.81	0.000
	Female	6.45 ± 0.47	4.79—7.69	
IFL	Male	7.44 ± 0.48	6.06—8.54	0.000
	Female	7.09 ± 0.49	5.93—8.23	
MFL	Male	8.43 ± 0.53	6.77—9.54	0.000
	Female	8.07 ± 0.57	6.80—9.26	
RFL	Male	7.84 ± 0.52	6.40—9.04	0.000
	Female	7.57 ± 0.55	5.98—8.71	
LFL	Male	6.22 ± 0.43	5.10—7.42	0.000
	Female	5.96 ± 0.48	4.84—7.15	

***TL** = Thumb length; **IFL** = Index finger length; **MFL** = Middle finger length; **RFL** = Ring finger length; **LFL** = Little finger length; **SD** = Standard deviation; **cm** = Centimetre; **p-value** = Probability value.*

CORRELATION BETWEEN RIGHT AND LEFT CLAVICULAR LENGTHS AND HEIGHT

In both males and females, clavicular lengths correlated positively and moderately with height and were statistically significant ($p < 0.01$). In males, right clavicular length correlated better with height ($r = 0.461$) than that of the left, but for females, it was left clavicular length ($r = 0.408$) (Table 3).

Table 3: Pearson's correlation between clavicular lengths and height in both sexes

	Sex	r
RCL	**Male**	**0.461****
	Female	**0.404****
LCL	**Male**	**0.438****
	Female	**0.408****

***RCL** = Right clavicular length; **LCL** = Left clavicular length; **p-value** = Probability value; r = Correlation coefficient; ** = Correlation is significant at 0.01 level (2-tailed).*

CORRELATION BETWEEN FINGER LENGTHS AND HEIGHT

Pearson's correlation between the left and right digit lengths in both sexes revealed that, in females, the best parameter that correlated with height was left ring finger length ($r = 0.373$), with that of the males being right middle finger length ($r = 0.347$) (Table 4). Matheswaran and Ranganath (2014), reported that, only the right and left index fingers better correlated positively with height. In that study, for females, only the right ring and middle fingers correlated better with height. This partially contradicts that of the present study in which correlation between the index fingers and height was weak. However, for the middle finger, the correlation with height was moderate in both studies.

Table 4: Pearson's correlation of right and left digit lengths and height in males and females

		RIGHT	LEFT
	Sex	r	r
TL	**Male**	**0.180***	**0.127**
	Female	**0.251***	**0.292***
IFL	**Male**	**0.262****	**0.264****
	Female	**0.335****	**0.371****
MFL	**Male**	**0.347****	**0.307****
	Female	**0.328****	**0.363****
RFL	**Male**	**0.282****	**0.245****
	Female	**0.329****	**0.373****
LFL	**Male**	**0.153**	**0.164**
	Female	**0.292****	**0.286****

***TL** = Thumb length; **IFL** = Index finger length; **MFL** = Middle finger length; **RFL** = Ring finger length; **LFL** = Little finger length; r = Correlation coefficient; * = Correlation is significant at the 0.05 level (2-tailed); ** = Correlation is significant at 0.01 level (2-tailed).*

REGRESSION ANALYSIS FOR HEIGHT ESTIMATION

Multiple regression analysis for height estimation derived equations for sex -specific and general population formulae as shown in Table 5. For the general population, the right clavicular and left middle finger lengths were utilised in the model for height estimation with a coefficient of determination of 0.458 which was better than the sex-specific formulae developed.

Table 5: Regression analysis for height estimation

Sex		Equation	SEE	R^2
Male	**RCL, RMFL**	**93.115 + 3.104(RCL) + 3.663(RMFL)**	**6.025**	**0.286**
Female	**LCL, LMFL**	**94.181 + 2.889(LCL) + 3.364(LMFL)**	**6.301**	**0.237**
Pooled	**RCL, LMFL**	**76.958 + 4.046(RCL) + 3.753(LMFL)**	**6.264**	**0.458**

***RCL** = Right clavicular length; **RMFL** = Right middle finger length; **LCL** = Left clavicular length; L**MFL** = Left middle finger length; SEE = Standard Error of Estimate*

CONCLUSION

Males were significantly taller than females. Again, males recorded significantly longer digits and clavicles than females. In both sexes, height correlated significantly with all the digit and clavicular lengths. Clavicular lengths correlated better with height than finger lengths. The best modelled equation for height estimation utilized right clavicular and left middle finger lengths.

REFERENCES

Ahuja, P., Manve, P., Christal G. and Dahiya, M. S. (2018). Estimation of Stature from finger Length. *Journal of Forensic Science and Criminal Investigation*, **7**(2): 1 – 4.

Bardale, R. V., Dahodwala, T. M. and Sonar, V. D. (2013). Estimation of stature from index and ring finger length. *Journal of Indian Academy of Forensic Medicine*, **35**(4): 353 – 357.

Baykal, B. and Turkkan, S. (2017). Development of the hand. *Journal of Embryology,* **1**(1): 1 – 5.

Bindhu, S. and Blessina, S. (2015). Sexual Dimorphism of Clavicle: A cross sectional study in south Indian population. *International Journal of Anatomy and Research*, **3**(3): 1249 – 1251.

Fink, B., Manning, J. T., Neave, N. and Tan, U. (2004). Second to fourth digit ratio and hand skill in Austrian children. *Biological Psychology*, **46**: 558 – 564.

Hisham, S., Mamat, C. R. and Ibrahim, M. A. (2012). Multivariate statistical analysis for race variation from foot anthropometry in the Malaysian population. *Australian Journal of Forensic Science*, **44**: 285 – 293.

Ilayperuma, I., Nanayakkara, G. and Palahepitiya, N. (2009). Prediction of personal stature based on the hand length. *Galle Medical Journal*, **14**(1): 15 – 18.

Kreitner, K. F., Schweden, F. J., Riepert, T., Nafe, B. and Thelen, M. (1998). Bone age determination based on the study of the medial extremity of the clavicle. *European Radiology Journal*, **8**: 1116 – 1122.

Krishan, K., Kanchan, T., Menezes, R. G. and Gosh, A. (2012). Forensic anthropology casework-essential methodological considerations in stature estimation. *Journal of Forensic Nursing*, **8**: 45 – 50**.**

Matheswaran, G. and Ranganath, V. (2014). Digit length displays a significant function in stature estimation: A study from coastal region of south India. *International Journal of Anatomy and Research,* **2**(2): 336 – 339.

Oladipo, G. S., Ezi, G., Okoh, P. D. and Abidoye, A. O. (2015). Index and ring finger lengths and their correlation with stature in a Nigerian population. *Annals of Bioanthropology*, **3**(1): 19 – 21.

Schulz, R., Muhler, M., Mutze, S., Schmidt, S., Reisinger, W. and Schmeling, A. (2005). Studies on the time frame for ossification of the medial epiphysis of the clavicle as revealed by CT scans. *International Journal of Legal Medicine*, **119**: 142 – 145.

Sen, J., Kanchan, T., Mondal, N. Ghosh, A. and Krishan, K. (2014). Estimation of stature from lengths of index and ring fingers in a North-eastern Indian population. *Journal of Forensic and Legal Medicine*, **22**: 10 – 15.

Singh, T. N., Singh, I. D., Devi, H. R. and Pfoze, K. (2015). Split Forearm and Hand- a case report. *Journal of Dental and Medical Sciences*, **14**(11): 20 – 22.

Weise, M., De-Levi, S., Barnes, K. M., Gafni, R. I., Abad, V. and Baron, J. (2001). Effects of estrogen on growth plate senescence and epiphyseal fusion. *Journal of Forensic Science International*, **98**(12): 6871 – 6876.

Zulkifly, N. R., Abd-Wahaba, R., Layangb, E., Ismailc, D., Syuhaila, W. N., Desac, M., Hishamd, S. and Mahata, N. A. (2018). Estimation of stature from hand and handprint measurements in Iban population in Sarawak, Malaysia and its applications in forensic investigation. *Journal of Forensic and Legal Medicine*, **53**: 35 – 45.