

# ASSESSMENT OF THE RELATIONSHIP BETWEEN MID-UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS

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## INTRODUCTION

The area of anthropometry covers a variety of human body dimensions such as body weight, height and size; comprising skin fold thicknesses, circumferences, lengths and breadths (McDowell *et al.*, 2008). Forensic identification of persons from dismembered, mutilated and fragmented body remains has become a challenge to forensic experts; under such circumstances, complete identification becomes impossible and therefore, partial identification is crucial to narrow the investigative and identification process (Kanchan *et al.*, 2008). This problem is increased in cases of mass disasters, explosions and assault cases where the body is dismembered thereby complicating identification (Kumar *et al.*, 2009). Dimensional relationship between body parts and the entire body has been of great interest to scientists, anatomists and anthropologists for several years (Pawar and Dadhich, 2012). In the field of forensic anthropometry, hand measurements and mid-upper arm circumference are of great importance (Raju *et al.*, 2014). These anthropometric indices have been employed in the determination of sex, height and malnutrition status among immune-compromised patients, pregnant women and children for clinical purposes in many developed countries. However, there is limited data on mid-upper arm circumference and hand measurements in Ghana. Therefore, the present study was conducted to assess the relationship between mid-upper arm circumference and hand measurements among undergraduate students of Kwame Nkrumah University of Science and Technology. The specific objectives were;

- To determine bilateral symmetry and sexual dimorphism of mid-upper arm circumference and hand measurements.
- To determine the correlation between mid-upper arm circumference and hand measurements.
- To derive a regression model to estimate mid-upper arm circumference from hand measurements

## MATERIALS AND METHODS

A total of 291 students were recruited from the School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology for the study. Participants for this study were selected randomly. Out of the selected participants, 172 (59.1%) were males and 119 (40.1%) were females within the age range of 16 – 34 years. Informed participant consent and ethics approval from the Committee for Human Research and Publications Ethics (CHRPE) were sought prior to the study. Individuals with no deformity or scar on the hand and upper arm were included in the study. Participants with abnormal upper limb morphologies were also excluded from the study. Mid-upper arm circumference (MUAC) was taken on the participants' arms, just at the mid-point between the acromion and the olecranon using a flexible, inelastic glass fibre measuring tape (Shanghai, China). Dimensions of the hand were taken by scanning the left and right hands of the participants using CanoScan LiDE 120 scanner (Canon USA) which was connected to an HP Envy i7 laptop. Measurements on the scanned hand prints were taken with the parallel dimensions tool of COREL DRAW X7. The hand dimensions measured included hand length, palm length, palm width and the digit lengths of finger I - V (Figure 1A and 1B).

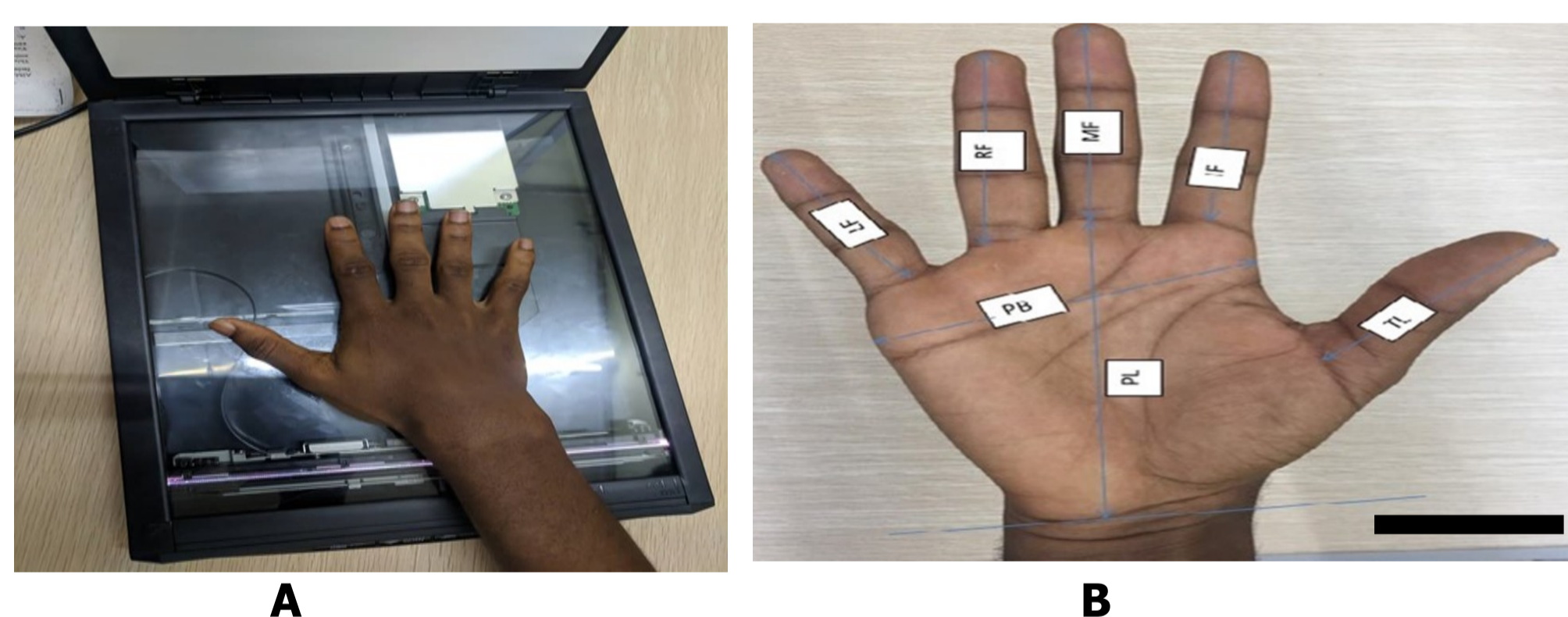


Figure 1: A) A picture showing scanning of the hand B) A scanned image showing the measurement of the hand (x0.2)

LFL = Little finger length, RFL = Ring finger length, MFL = Middle finger, IRL = Index finger length, TL = Thumb length, PL = Palm length, PB = Palm Breadth

## DATA ANALYSIS

The data were compiled, tabulated and coded on a Microsoft Excel spreadsheet version 2013. The data collected were analysed statistically using the programme IBM Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics was performed to ascertain the mean, standard deviation and the range of the measured MUAC and hand dimensions. The relationship between mid-upper arm circumference and hand measurements was determined using regression analysis. The level of statistical significance was determined at  $P < 0.05$  or 95% confidence interval.

## RESULTS AND DISCUSSION

### SAMPLE STATISTICS

The present study consisted of 291 participants, comprising 172 (59.1 %) males and 119 (40.9%) females. The ages of the participants ranged from 16-34 years with a mean of  $19.58 \pm 1.96$  years. The means of the right and left MUAC were  $27.57 \pm 3.35$  cm and  $27.33 \pm 3.30$  cm respectively.

### BILATERAL ASSYMMETRY OF THE MID UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS

The mean of the right mid-upper arm circumference was significantly greater than that of the left (Table 1). Handedness has been reported to have an effect on mid-upper arm circumference because the muscles (triceps and biceps) of the dominant arm hypertrophy due to frequent use. This in turn cause the dominant arm to have a higher circumference than the contralateral arm (Blackwell *et al.*, 2015). Also, with the exception of the ring finger, all the hand

dimensions exhibited bilateral asymmetry. Tarsem *et al.* (2015) also reported similar findings, however, the left hand dimensions were greater than corresponding measurements on the right.

TABLE 1: BILATERAL ASSYMMETRY OF THE MID UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS

MEASUREMENTS	MEAN + SD (cm)		p - value
	LEFT	RIGHT	
MUAC	27.33 ± 3.30	27.57 ± 3.35	0.000
THUMB LENGTH	6.61 ± 0.50	6.65 ± 0.50	0.003
INDEX FINGER LENGTH	7.34 ± 0.52	7.31 ± 0.51	0.002
MIDDLE FINGER LENGTH	8.32 ± 0.58	8.29 ± 0.58	0.004
RING FINGER LENGTH	7.76 ± 0.58	7.75 ± 0.56	0.203
LITTLE FINGER LENGTH	6.17 ± 0.51	6.14 ± 0.49	0.004
HAND LENGTH	19.54 ± 1.19	19.45 ± 1.16	0.000
HAND BREADTH	8.71 ± 0.53	8.75 ± 0.57	0.002
PALM LENGTH	11.22 ± 0.72	11.16 ± 0.71	0.001

Cm = Centimeters, SD = Standard deviation, P-Value = Probability value, MUAC = mid upper arm circumference

### SEXUAL DIMORPHISM OF THE MID UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS

The mean left and right hand measurements recorded for males were significantly greater than that of the females ( $p < 0.05$ ). Similarly, Agnihotri *et al.* (2005) found the hand dimensions of males to be about 1cm greater than the females. The difference could be attributed to the early attainment of maturity in adolescent females. Also, males engage in strenuous activities than females (Aboul-Hagag *et al.*, 2011). Mid-upper arm circumference was greater in males than in females for the left and right arms. However, the mean difference was not statistically significant ( $p > 0.05$ ). This finding is in contrast with Benítez *et al.* (2016) who rather observed significant difference between males and females ( $p < 0.05$ ).

TABLE 2: SEXUAL DIMORPHISM OF THE MID UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS

	MEASUREMENTS	MEAN + SD (cm)		p - value
		MALES	FEMALES	
LEFT	MUAC	27.54 ± 3.37	27.02 ± 3.37	0.190
	THUMB LENGTH	6.75 ± 0.47	6.40 ± 0.47	0.000
	INDEX FINGER LENGTH	7.50 ± 0.47	7.12 ± 0.51	0.000
	MIDDLE FINGER LENGTH	8.48 ± 0.53	8.09 ± 0.57	0.000
	RING FINGER LENGTH	7.91 ± 0.53	7.55 ± 0.59	0.000
	LITTLE FINGER LENGTH	6.31 ± 0.47	5.96 ± 0.50	0.000
	HAND LENGTH	19.97 ± 1.01	18.92 ± 1.17	0.000
	HAND BREADTH	8.89 ± 0.48	8.44 ± 0.50	0.000
	PALM LENGTH	11.49 ± 0.61	10.83 ± 0.70	0.000
	RIGHT	MUAC	27.73 ± 3.27	27.34 ± 3.47
THUMB LENGTH		6.80 ± 0.47	6.44 ± 0.46	0.000
INDEX FINGER LENGTH		7.46 ± 0.47	7.10 ± 0.49	0.000
MIDDLE FINGER LENGTH		8.46 ± 0.54	8.06 ± 0.56	0.000
RING FINGER LENGTH		7.89 ± 0.52	7.55 ± 0.55	0.000
LITTLE FINGER LENGTH		6.27 ± 0.44	6.27 ± 0.44	0.000
HAND LENGTH		19.89 ± 0.97	18.82 ± 1.12	0.000
HAND BREADTH		8.94 ± 0.49	8.48 ± 0.51	0.000
PALM LENGTH		11.43 ± 0.59	10.77 ± 0.69	0.000

Cm = Centimeters, SD = Standard deviation, P-Value = Probability value, MUAC = mid upper arm circumference

### CORRELATION BETWEEN MID-UPPER ARM CIRCUMFERENCE AND HAND MEASUREMENTS.

There was a very weak positive correlation between left MUAC and all the dimensions of the hand with the highest correlation coefficient recorded for the right hand breadth ( $r = 0.313$ ,  $p < 0.05$ ) (Table 3). The right MUAC also showed a weak positive correlation with hand dimensions (Table 4). Again, right hand breadth showed the highest correlation ( $r = 0.338$ ,  $p < 0.05$ ) with right MUAC. This weak correlation observed may be due to the fact that most of the human activities done with the hand also involve the arm. Therefore an increase in the size of the hand may have a resultant effect on the muscles of the arm causing them to hypertrophy (Blackwell *et al.*, 2015).

TABLE 3: CORRELATION BETWEEN LEFT MID UPPER ARM CIRCUMFERENCE AND HAND DIMENSIONS

Hand Measurements	Left		Right	
	r	p-value	r	p-value
THUMB LENGTH	0.154	0.008	0.143	0.015
INDEX FINGER LENGTH	0.184	0.002	0.168	0.004
MIDDLE FINGER LENGTH	0.172	0.003	0.162	0.005
RING FINGER LENGTH	0.167	0.004	0.160	0.006
LITTLE FINGER LENGTH	0.153	0.009	0.158	0.007
PALM LENGTH	0.196	0.001	0.184	0.002
HAND LENGTH	0.205	0.000	0.196	0.001
HAND BREADTH	0.287	0.000	0.313	0.000

LMUAC = left mid-upper arm circumference, r = coefficient of correlation, P-Value = Probability value

TABLE 4: CORRELATION BETWEEN RIGHT MID UPPER ARM CIRCUMFERENCE AND HAND DIMENSIONS

Hand Measurements	Left		Right	
	r	p-value	r	p-value
THUMB LENGTH	0.161	0.006	0.153	0.009
INDEX FINGER LENGTH	0.191	0.001	0.180	0.002
MIDDLE FINGER LENGTH	0.181	0.002	0.173	0.003
RING FINGER LENGTH	0.176	0.003	0.176	0.003
LITTLE FINGER LENGTH	0.178	0.002	0.184	0.002
PALM LENGTH	0.196	0.001	0.178	0.002
HAND LENGTH	0.209	0.000	0.197	0.001
HAND BREADTH	0.283	0.000	0.338	0.000

RMUAC = right mid-upper arm circumference, r = coefficient of correlation, P-Value = Probability value

### ESTIMATION OF MID UPPER ARM CIRCUMFERENCE FROM THE HAND DIMENSIONS

Among the measured hand dimensions, right hand breadth was the best estimator of MUAC (Adjusted  $R^2 = 0.111$ ,  $SEE = 3.16$ ), although all hand dimensions exhibited weak correlation with mid upper arm circumference. The regression model for estimating the MUAC was

$$MUAC = 1.775 (RHB) + 12.113$$

Where RHB is right hand breadth and MUAC is mid upper arm circumference.

## CONCLUSION

In the present study, right mid-upper arm circumference was greater than the left mid-upper arm circumference. Mid-upper arm circumference was statistically greater in males than females. All hand measurements were greater in males than in females. With respect to the hand dimension, the means of all parameters of the left hand were statistically greater than that of the right hand except for hand breadth and thumb length which were greater in the right hand. There was a weak relationship between hand measurement and mid-upper arm circumference with weak correlation. Therefore, hand measurements were not reliable estimators of mid upper arm circumference. The results of the present study provide useful data for future studies.

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