THE PREDICTIVE ROLE OF PERCUTANEOUS HAND LENGTH IN STATURE ESTIMATION OF AN ADULT NIGERIAN POPULATION

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ABSTRACT

Background: Anthropometry of the living, historically recognized as being an essential element of physical anthropology because of its role in classifying the biological characteristics of humans is being re-evaluated for its potential contribution to forensic investigations. This study sought to derive regression equations and multiplication factors for stature prediction using percutaneous hand length measurement of adult Nigerians in Nnewi.

Materials and Methods: The cross-sectional study comprised a random sample of 800 subjects (400 males and 400 females) of Nigerian parentage, aged 18-50 years who volunteered and satisfied the inclusion criteria. Ethical clearance was sought and obtained; and measurements which included stature and hand length were measured with an anthropometer and a small sliding vernier caliper respectively, upon full consent of the participants. The data collated was analyzed using SPSS version 20.

Results: Mean stature values of 175.12±6.61cm, 165.53±6.69cm and 170.33±8.19cm were recorded for the males, females and the pooled sample respectively. The mean values of the right, left and combined hand lengths in the males, females and the pooled sample ranged from 19.67±0.94cm to 20.91±0.77cm. Independent *t* test exhibited statistically significant gender differences (*P*<0.05) for all the parameters, with the males having consistently higher values than the females. Paired *t* test revealed the existence of bi-lateral asymmetry between right and left hand lengths in the males and the pooled sample (*P*<0.05). Significant positive correlation coefficients of stature with hand length were found to range from 0.569 to 0.739 in the study. The multiplication factors computed for stature prediction from hand length ranged from 8.375 to 8.450 in the males, females and the pooled sample.

Conclusion: This study has demonstrated that stature can be predicted from hand length. The prediction models established from this study will be very useful in disaster victim identification from mutilated human remains in Nigeria.

KEY WORDS: Stature, Hand length, Forensic, Regression, Nigeria.

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INTRODUCTION

It is generally accepted that the most accurate

biological profiles are formulated using contemporary population-specific standards. This issue

has been considered many times in the literature and basically relates to population-specific variability in the relative expression of morphological characteristics used to estimate sex, age, and stature. Population variability is also not temporarily static, thus contemporary standards, devised on modern representative samples are required, and secular trends in stature are an example of the importance of such contemporary forensic standards [1]. Stature prediction occupies relatively a central position both in anthropological research and in identification necessitated by medical jurisprudence or by medico-legal experts [2].

There is an established relationship between stature and various body parts such as the head, trunk, upper and lower extremities. This allows forensic scientists to estimate stature from different parts of the body [3].

Among the various parameters of identification, an individual's stature is an inherent characteristic, the estimate of which is considered to be important in cases such as earthquakes, auto crash, deliberate mutilation, flooding and other man-made and natural disasters where only fragmentary or mutilated remains of unknown decedents are recovered [4]. Estimation of stature from different dimensions has considerable forensic value, not only for identification of skeletal remains, but also in developing descriptions of suspects from evidence at the scene of a crime and in corroborating height estimates from witnesses [5].

A plethora of scientific research on adult stature prediction from different anthropometric parameters, including the dimensions of the hand [1,2,4,6-19] abound in the literature, where it has been reported that there exist significant correlations between stature and hand dimensions from such studies in different climes. Research assessing the predictive role of hand dimensions in stature estimation of adult Nigerian populations have also been carried out and reported in the literature [20-24]. However, the aforementioned Nigerian based studies involved adult samples restricted to specified Nigerian ethnic groups. Therefore, it will be useful to examine the relationship between stature and hand length in a Nigerian population, comprising an adult sample from a variety

of ethnic backgrounds. Also, the present study made an attempt to predict stature using combined hand length, which can be applicable when both hands of mutilated human remains are recovered in forensic contexts. Hence, this study aimed to predict stature using right, left and combined hand lengths of adult Nigerians of different ethnic nationalities, resident in Nnewi, Anambra state, Nigeria.

MATERIALS AND METHODS

Study population: This descriptive cross-sectional study involved adult Nigerians of different ethnic nationalities, resident in Nnewi, Anambra state, Nigeria. A total of 800 volunteers (400 males & 400 females), aged 18-50 years were recruited for this research work using a simple random sampling technique.

The participants were selected from the College of Health Sciences, Nnamdi Azikiwe University, Nnewi campus, and Nnamdi Azikiwe University Teaching Hospital, Nnewi. Participants were also selected from some homes and work places.

Study area: Nnewi is the second largest city in Anambra State in South-East Nigeria. It lies within the latitude 6° 12' 03" N and longitude 6° 55' 03" E. The city spans over 1076.9 square miles (2789 km²) in Anambra State. Nnewi is a fast-developing city and a major industrial and commercial hub in Africa due to its vast economic activities that include agriculture, forestry, and rapid industrialization, especially in the auto parts sector. Being a metropolitan city, it is home to many Nigerians of diverse cultures, religion, and ethnicity.

Eligibility criteria: The participants were required to have knowledge of their age and the ethnocultural distribution of their biological parentage. Excluded from the study were subjects who do not have both parents of Nigerian ancestry, and also those who presented apparent symptomatic musculoskeletal, dermatological or congenital deformity that might affect stature and hand length measurements.

Ethical approval and informed consent: In accordance with the Belmont declaration of 1979, ethical approval to conduct this research was sought and obtained from the Research and Ethics Committee, Faculty of Basic Medical

Sciences, Nnamdi Azikiwe University, Nigeria, prior to the commencement of sampling and measurements.

The procedures were explained to the participants, and once full oral consent was obtained, the participants were screened in line with the inclusion criteria. The right to withdraw, if so desired at any stage of the study was also clearly stated to the participants.

Demographics: Sampling variables including gender, age, hand length and stature were recorded on an anthropometric proforma.

Fig. 1: Anatomical landmarks for hand length measurement.

Fig. 2: Measurement of hand length.

Anthropometry

Materials

a) Anthropometer: This instrument, a customized portable wooden anthropometer, with a measuring range of 0 – 220 cm was used for stature measurement of the study subjects.

b) Small sliding vernier caliper: The small vernier caliper (Sliding) used is an authentic Mitutoyo product (Japan) which has been certified and conducts quality assurance under ISO 9000 quality system. It has the serial number: VN – AA. For the present study, the small sliding vernier caliper was used for the measurement of percutaneous hand length.

Measurements: The anthropometric protocol adopted for stature and percutaneous hand length measurements were according to Weiner and Lourie [25].

a) Stature: Standing barefooted on the base of the anthropometer, with the heels together and arms adducted, the participant was made to stretch upward to the fullest extent. Once the head is held in the Frankfurt plane, the movable piece of anthropometer was then brought in contact with the vertex in the mid-sagittal plane.

b) Hand length: The length of the hand was measured from the midpoint of the distal wrist crease to the dactylion / the most projecting point of the middle finger (figure 1), with the palmar surface of the hand facing upward, the fingers together, and the thumb abducted (figure 2).

All the values obtained were recorded to the nearest 0.1cm. The measurements were taken by one researcher (principal author) to minimize inter-observer bias. Also, the measurements were taken twice and an average of the two calculated. To ensure repeatability, the intra-tester technical error of measurement (TEM) was estimated to determine the error intrinsic to the study and the value obtained showed acceptable degree of reliability.

Statistical Analysis:

The data collated was analyzed using statistical package for the social sciences (SPSS) for windows, version 20.0, Armonk, New York: IBM Corporation. Kolmogorov-Smirnov test was employed to test the normality of the sample. Mean, standard deviation, standard errors of estimate, independent and paired *t* - tests were used as statistical tools to analyze the data. Comparisons were made of stature and right hand length (RHL), left hand length (LHL) and the combined hand length (CHL) between the males and females using the Student's (independent) *t* - test

to ascertain if sexual dimorphism exist in the study. The independent *t* test was also employed to test if there exist statistically significant differences between measured and estimated stature values. The comparison made between corresponding right and left hand length of each subject was aimed at determining if bi-lateral asymmetry exists, and this was carried out using the Paired *t* - test. The differences were considered statistically significant at 95% confidence level (i.e., when $P < 0.05$). Correlation coefficients (*r*), the standard measure of association between stature and the various parameters were determined for the male and female subjects, and also for the whole population. Multiplication factors, which in this study are the mathematical relationships between stature and hand length were also determined for the subjects; $M.F = \text{Stature} \div \text{hand length}$. Linear regression equations were also derived using the variables and this served as the predictive models for stature estimation.

RESULTS

The results obtained from this study were summarized using the tables. The Kolmogorov-Smirnov test revealed normal distribution of the data, with the test statistics found not to be statistically significant ($P > 0.05$) for all the parameters employed in the study.

Table 1 shows the summary of the descriptive and inferential statistics of age, stature, right, left and combined hand lengths; presented as Mean $\pm$ SD for the males, females and the pooled sample. It can be observed that from the study, the mean stature recorded values of 175.12 ± 6.61 cm, 165.53 ± 6.69 cm and 170.33 ± 8.19 cm for the males, females and the pooled sample, respectively. Maximum values for the right, left and combined hand lengths were recorded for the male sample, with values of 20.79 ± 0.84 cm, 20.91 ± 0.77 cm and 20.85 ± 0.77 cm respectively. The pooled sample exhibited lower mean age than the male sample, and higher mean age than the female sample.

From table 2, it can be observed that gender differences in age, stature, right, left and combined hand lengths were statistically significant, with the males having consistently higher values than the females ($P < 0.05$). The LHL

recorded the highest *t* value, while the lowest *t* value was reported for age, with values of 20.47 and 8.92 respectively.

Table 1: Summary of the descriptive statistics of age, stature and hand lengths of the males, females and the pooled sample.

Descriptives	Males (n = 400)		Females (n = 400)		Pooled sample (n = 800)	
	Mean	$\pm$ SD	Mean	$\pm$ SD	Mean	$\pm$ SD
Age (years)	35.68	2.96	33.97	2.44	34.83	2.76
Stature (cm)	175.12	6.61	165.53	6.69	170.33	8.19
RHL (cm)	20.79	0.84	19.95	1	20.37	1.09
LHL (cm)	20.61	0.77	19.92	0.94	20.26	1.05
CHL (cm)	20.7	0.77	19.94	0.94	20.32	1.2

RHL = Right hand length, LHL = Left hand length, CHL = Combined hand length (RHL+LHL)/2, SD = Standard deviation.

Table 2: Gender differences in age, stature, right, left and combined hand lengths of the study population.

Parameters (cm)	Gender differences			
	<i>t</i> - statistic	<i>P</i> - value	$\pm$ MD	$\pm$ SED
Age (years)	8.92*	0.000	1.7	0.19
Stature	20.37*	0.000	9.58	0.47
RHL	18.39*	0.000	1.19	0.06
LHL	20.47*	0.000	1.24	0.06
CHL	17.30*	0.000	1.21	0.07

RHL = Right hand length, LHL = Left hand length, CHL = Combined hand length (RHL+LHL)/2, MD = Mean difference, SED = Standard error of difference, * ($P < 0.05$).

Table 3 shows the existence of bi-lateral differences between the right and left hand lengths in the males and the pooled sample ($P < 0.05$). The significance level recorded for the females indicated the non-existence of significant bi-lateral asymmetry between the right and left hand lengths. For the males, females and the pooled sample, it can be observed that the right hand is greater than the left hand, as the *t* statistic exhibited positive values, with statistical significance recorded for the males and the pooled sample, as indicated by the *P* values.

Table 4 presents the association between stature and the hand lengths, evaluated using Pearson's correlation. It can be observed from the table, that the right, left and combined hand lengths exhibited positive significant correlations with stature in the males, females and the pooled sample. The maximum correlation coefficient value was recorded for the CHL in the pooled sample, while the minimum correlation

Table 3: Bi-lateral differences (right – left) in hand length of the males, females and the pooled sample.

RHL = Right hand length,
LHL = Left hand length,
SEM = Standard error of
mean. *($P < 0.05$).

Sample	Paired parameter (cm)	t - statistic	Sig. level	Paired differences	
				Mean (cm) (2 tailed)	± SEM (cm)
Males (n = 400)	RHL – LHL	3.00*	0.003	0.017	0.056
Females (n = 400)	RHL - LHL	0.001	0.999	0.008	0.999
Pooled sample (n = 800)	RHL - LHL	5.48*	0.000	0.095	0.017

Table 4: Pearson's correlation coefficients of stature with hand lengths of the males, females and the pooled sample.

RHL = Right hand length,
LHL = Left hand length,
CHL = Combined hand length
(RHL+LHL)/2. *($P < 0.05$).

Sample	Parameters	Correlation coefficient (r)	P - value
Males (n = 400)	RHL	0.569*	0.000
	LHL	0.590*	0.000
	CHL	0.602*	0.000
Females (n = 400)	RHL	0.585*	0.000
	LHL	0.602*	0.000
	CHL	0.613*	0.000
Pooled sample (n = 800)	RHL	0.710*	0.000
	LHL	0.734*	0.000
	CHL	0.739*	0.000

Table 5: Linear regression equations and multiplication factors for stature estimation using right, left and combined hand lengths.

RHL = Right hand length,
LHL = Left hand length,
CHL = Combined hand length
(RHL+LHL)/2, SEE = Standard error
of estimate.

Sample	Parameters (cm)	LINEAR REGRESSION EQUATIONS		MULTIPLICATION FACTORS (cm)
		Linear regression equations (cm)	±SEE (cm)	
Males (n = 400)	RHL	81.574 + 4.50 (RHL)	5.448	8.375
	LHL	69.320 + 5.06 (LHL)	5.346	8.375
	CHL	67.689 + 5.15 (CHL)	5.289	8.397
Females (n = 400)	RHL	88.739 + 3.92 (RHL)	5.431	8.45
	LHL	80.930 + 4.30 (LHL)	5.35	8.415
	CHL	79.494 + 4.38 (CHL)	5.294	8.433
Pooled sample (n = 400)	RHL	62.235 + 5.304 (RHL)	5.77	8.397
	LHL	55.079 + 5.681 (LHL)	5.574	8.433
	CHL	73.074 + 4.812 (CHL)	5.492	8.415

Table 6: Comparison of the mean measured and estimated stature values from the linear regression equations using independent t test.

RHL = Right hand length,
LHL = Left hand length,
CHL = Combined hand length
(RHL+LHL)/2, *($P < 0.05$),
ns = not significant.

Sample	Parameters	Measured stature (cm)	Estimated stature (cm)	Significance (2 tailed)
Males (n = 400)	RHL	175.12 ± 6.61	175.13 ± 6.43	0.977 ^{ns}
	LHL	175.12 ± 6.61	175.12 ± 6.20	0.993 ^{ns}
	CHL	175.12 ± 6.61	175.14 ± 6.28	0.946 ^{ns}
Females (n = 400)	RHL	165.53 ± 6.69	165.53 ± 6.94	0.980 ^{ns}
	LHL	165.53 ± 6.69	165.55 ± 6.88	0.948 ^{ns}
	CHL	165.53 ± 6.69	165.53 ± 6.82	0.990 ^{ns}
Pooled sample (n = 400)	RHL	170.34 ± 8.19	170.37 ± 7.98	0.899 ^{ns}
	LHL	170.34 ± 8.19	170.34 ± 7.24	0.992 ^{ns}
	CHL	170.34 ± 8.19	170.30 ± 7.50	0.902 ^{ns}

coefficient value was exhibited by the RHL in the males. The pooled sample showed higher correlation coefficient values (0.710 – 0.739) than the females (0.585 – 0.613), which in turn exhibited higher coefficient values than the male sample (0.569 – 0.602). Table 5 presents the linear regression equations and multiplication factors for stature estimation from hand length. It can be observed that the equations devised for the CHL in the males, females and the pooled sample recorded the least S.E.E values, hence indicating that the CHL provided the most reliable measures of stature prediction from the parameters employed in the study. It can also be seen that the maximum and minimum multiplication factor (MF) values were recorded for the RHL in the females and the right and left hand lengths in the males.

The accuracy and applicability of the regression equations was verified by comparing the actual stature with the estimated stature values obtained using the hand length dimensions as the independent variables, as presented in table 6. It was observed that the measured and estimated stature values lie in very close approximation. Independent *t* test revealed no statistically significant difference between the measured, and estimated stature values from all the hand length parameters in the males, females and the pooled sample. This indicates that the hand length can be reliably employed in stature prediction in medico-legal contexts.

DISCUSSION

There is a long record of discussion on the issue of human variation in anthropometric research. Caucasian standards have, by default, become the international standard, because most long-term anthropometric data available are from Caucasian populations, but there is mounting evidence that these Western standards may not be applicable to all. It is therefore agreed, that different formulae will be required for calculating stature from different segments in different populations [26].

Mean stature and hand length values were recorded for the males, females and the pooled sample of the present study. When compared with the reports from other similar studies, it

can be found that the present study exhibited greater anthropometric values than the Western Australians [1], Southern Chinese [7], Northern Indians [14], Iban ethnics of Malaysia [27], Sri Lankans [28] and adult Turks [29]. The variations observed, emphasizes the underlying influence of genetics, geographical distribution, nutrition, primary racial characteristics and a wide array of environmental factors impacting human growth and development [30]. This finding further highlights also, the observation by Samira *et al.* [26] that higher values in body dimensions are discovered in Negroid populations, thereby, necessitating the establishment of population specific predictive models for different populations around the world.

From the present study, sexual dimorphism in stature and hand lengths were found to be statistically significant, with the males exhibiting greater values than the females. This is in tandem with the findings from previous studies [14,16,20,22-24,27-29], which all reported the existence of gender differences in stature and hand length, with the males recording statistically significant higher anthropometric values. This finding made it pertinent, for sex-specific algorithms for stature prediction using hand length to be established in the present study. These differences could be attributed to hormonal influences, which causes earlier cessation of bone growth in the females than the males, causing the males to have two or more years of bony growth than the females [31,32].

The present study recorded bi-lateral differences in hand lengths of the males and the pooled sample. The female sample did not exhibit significant bi-lateral asymmetry for hand length. The reports for the males and the pooled sample is congruent with the findings of Ishak *et al.* [1], Rastogi *et al.* [18] and Krishan and Sharma [38] which reported the existence of bi-lateral differences in hand length from their respective studies. In their study on a north Indian population, Krishan and Sharma [14] reported no statistically significant bi-lateral difference for hand length, though the right hand presented higher mean values than the left hand. Tang *et al.* [7] in a similar study in Southern China, reported statistically significant bi-lateral asymmetry in the females, and also recorded

bi-lateral symmetry in the males, findings which are contrary and in reverse with the report of the present study. The bi-lateral differences could be due to handedness, as the present study considered only right handed individuals. Hence, the reason for the greater right hand values than the left, as the dominant use of the right hand (directional asymmetry) for daily physical activities will likely lead to greater development and musculature of the right hand [39].

The present study has shown the existence of significant correlations between hand length and stature in an adult Nigerian population. Consistent with this finding are reports from similar studies [22,24,28,29,33-37] which all recorded that stature is significantly correlated with hand length. Jasuja and Singh [36] and Jitendra *et al.* [37] reported lower correlation coefficient values for the right and left hand lengths with stature in the males and females, than was obtainable in the present study, with values ranging from ($r = 0.452 - 0.557$) and ($r = 0.504 - 0.5120$) respectively. Pandit and Sharma [34] reported higher correlation coefficient values than was recorded for the present study, with values ranging from ($r = 0.63 - 0.71$) for the right and left hand lengths of the males and the females. Krishan and Sharma [14] reported correlation coefficient values ranging from ($r = 0.599 - 0.686$) for the right and left hand lengths of male and female Rajputs of North India. These studies which recorded higher [14,34] and lower [36,37] correlation coefficient values than the present study indicates greater and lesser association respectively, between stature and hand lengths when compared with the present study.

The present study found the MF values for stature estimation from hand length to be greater in females than in the males. This is not in consonance with the findings of Manpreet *et al.* [11] where male:female ratio was found to be 9.361 and 8.679 for the males and females, respectively. The study by Jitendra *et al.* [37] found male:female ratio for stature estimation from hand length in the males to be lower than that of the females. This is in tandem with the findings from the present study where male:female ratio exhibited greater values in

the females than in the males.

SEE values from the regression equations were derived for the estimation of stature from hand length of the males, females, and the pooled sample of this study. Considering the right and left hand lengths, it can be observed that the LHL in the males, females and the pooled sample exhibited lesser SEE values than the RHL, hence, indicating that the LHL is more reliable for stature estimation than the RHL in the present study. This is consistent with the findings of Krishan and Sharma [14] and Moorthy and Zulkifly [33] which reported the LHL to exhibit lower SEE values than the RHL in the males and females, except for the females in the former [14] which had higher SEE value for the left hand than the right hand. With lower SEE ranges ($\pm 4.465 - \pm 4.757$) and ($\pm 3.82 - \pm 5.22$) for the right and left hands in the males and the females than was obtained in the present study, it can be said that the studies [14,33] respectively, predicted stature from hand length more accurately, than the present study.

Generally, it can be observed that when compared to the right and left hand lengths, the combined hand length (CHL) in the males, females and the pooled sample exhibited greater correlation coefficient values, and also exhibited the least values for standard errors of estimate in the study. This shows that the CHL is the most reliable parameter for stature prediction in the present study.

CONCLUSION

The present study has demonstrated the usefulness of right, left and combined hand lengths for stature prediction in an adult Nigerian population. The established predictive models can be useful in identifications necessitated by medico-legal jurisprudence. It is worthy to note that the present study found the combined hand length to be more reliable for stature prediction than the right and left hand lengths. Further research on stature prediction from hand length, including the combined hand length in adult Nigerian populations are recommended.

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ABBREVIATIONS

RHL – Right hand length

LHL – Left hand length

CHL – Combined hand length

SD – Standard deviation

Conflicts of Interests: None

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