

# Sexual Dimorphism in Hand and Foot Length, Indices, Stature-ratio and Relationship to Height in Nigerians

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## Abstract

Studies have established sexual dimorphism in hand and foot lengths for forensic applications. The present investigation was conducted to study hand and foot lengths, stature ratio and indices for sex differences. Data for the study were obtained from 250 males (mean age  $24.50 \pm 2.82$ ) and 150 females (mean age  $22.22 \pm 1.99$ ) randomly selected students of the Ahmadu Bello University, Zaria, Nigeria. Height, length and width of hand and foot were measured following standard protocols. In all anthropometric parameters measured or calculated males were significantly ( $P < 0.001$ ) higher. Significant relationships were established between hand and foot lengths in both sexes. Multiple linear regression analysis of hand and foot lengths generated predictive equations with statistical significant ( $P < 0.001$ ) ability for height prediction. Height could be accurately predicted from a combination of right and left hand and foot lengths which will be useful in forensic investigation.

## INTRODUCTION

Ascertaining sex and estimation of stature from incomplete skeletal and decomposing bodies is a recurring theme in physical anthropology and forensic science (1, 2, 3, 4). This has become useful in recent times due to mass disasters like plane crash, mass suicide, tsunamis, forest fires, earth quakes (5). Relationship between different body parts especially the limbs is being used to establish sex and stature (4, 5, 6, 7), which is a prerequisite to identification in forensic investigation. Specifically hand and foot have been used by many investigators to determine sex and estimate stature (1, 4, 6, 8, 9). Parameters that have been employed for this purpose include hand and foot length (2, 6, 8), and foot indices (1, 10).

The aim of this study is to investigate the sexual dimorphism in the hand and foot lengths, hand and foot indices, hand and foot-stature ratio and to determine the relationship between hand and foot lengths to stature in a sample of Nigerian population.

## MATERIALS AND METHODS

### SUBJECTS

This study was carried out on a cross sectional sample of 400 students (250 males with mean age  $24.50 \pm 2.82$  and 150 females with mean age  $22.22 \pm 2.00$ ) of the Ahmadu Bello University, Zaria, Nigeria. Samples were drawn

randomly across the student population, after giving informed consent to participate in the study.

### ANTHROPOMETRY

Anthropometric measurements of height, hand length and width and foot length and width were obtained following the description of Krishan and Sharma (6). The foot index was calculated as foot breadth/foot length x 100 as described by Agnihotri et al (1). Hand and foot to stature ratio were calculated by dividing the lengths of the hand and foot by the height of the subject as described by Fessler et al (10).

### STATISTICAL ANALYSIS

Data are expressed as means  $\pm$  standard deviation. Differences in hand and foot length and breadth were determined using Students paired and unpaired t-test relationship between body proportion and in males and females are obtained using Pearson correlation coefficient. Multiple linear regression analysis was used to generate predictive equations of height from hand and foot lengths. Differences were declared significant when  $P < 0.05$ . SigmaStat 2.0 (Systat Inc, Point Richmond, CA) was used for the statistical analysis.

### RESULTS

The mean and standard deviation as well as the t and P values of the anthropometric characteristics of the subjects are presented in Table 1. The anthropometric characteristics

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show significant difference with  $P < 0.001$ . Hand and foot length ratios are presented in Table 2. The ratios are higher in the female with statistical significant difference in the right hand and left foot length. Considering the ratios in the same sex left hand with stature ratio is significantly higher than the right, while no such differences were observed in the females. Foot length stature ratio only showed significant difference in the females ( $P = 0.01$ ).

**Figure 1**

Table 1: Anthropometric characteristics of subjects.

	Males n = 250	Females n = 150	t	P
Height (cm)	173.73 ± 7.13	160.00 ± 6.22	19.39	<0.001
Right hand length (cm)	19.85 ± 0.86	18.51 ± 0.66	16.41	<0.001
Left Hand length (cm)	19.93 ± 0.93	18.52 ± 0.77	15.62	<0.001
Right hand width (cm)	8.90 ± 0.95	7.82 ± 0.49	12.98	<0.001
Left hand width (cm)	8.68 ± 0.92	7.72 ± 0.46	11.87	<0.001
Right foot length (cm)	28.39 ± 1.73	24.52 ± 9.08	12.03	<0.001
Left foot length (cm)	26.42 ± 1.60	24.70 ± 1.10	11.62	<0.001
Right foot width (cm)	9.02 ± 0.72	8.23 ± 0.63	10.79	<0.001
Left foot width (cm)	9.09 ± 0.94	8.11 ± 1.00	9.79	<0.001

**Figure 2**

Table 2: Hand and foot length to stature ratio in males and females.

	Males n = 250	Females n = 150	t	P
Right hand length	0.11 ± 0.005	0.12 ± 0.004	2.89	0.004
Left hand length	0.12 ± 0.005	0.12 ± 0.005	1.95	0.05
	<b>t = -3.45 &amp; P=0.001</b>	<b>t = -0.90 &amp; P=0.92</b>		
Right foot length	0.152 ± 0.007	0.153 ± 0.005	-1.58	0.12
Left foot length	0.152 ± 0.007	0.154 ± 0.007	-2.98	0.003
	<b>t = -0.15 &amp; P=0.85</b>	<b>t = -2.57 &amp; P=0.01</b>		

*t and P values in bold print denote statistical significant levels in the right and left hand and foot of the respective sexes.*

Hand and foot indices for right and left hand and foot for both males and females are presented in Table 3. For both hand and foot the indices are significantly ( $P < 0.05$  and  $< 0.001$ ) higher in the males than the females. But within the same sex males did not show significant difference in the hand index, but significant ( $P < 0.001$ ) difference was observed in the foot. For females both hand and foot indices were significantly ( $P < 0.001$ ) different.

**Figure 3**

Table 3: Hand and foot indices in males and females.

	Males n = 250 (Range)	Females n = 150 (Range)	t	P
Right Hand index	44.92 ± 5.15 (37.50 – 50.79)	42.27 ± 2.67 (37.31 – 47.87)	-9.59	<0.001
Left Hand index	43.65 ± 5.15 (36.32 – 48.24)	41.74 ± 2.34 (36.46 – 46.71)	-6.26	<0.001
	<b>t = 13.76, P &lt; 0.001</b>	<b>t = 3.63, P &lt; 0.001</b>		
Right Foot index	34.17 ± 2.67 (28.90 – 46.29)	33.65 ± 2.19 (28.74 – 37.96)	-1.99	<0.05
Left foot index	34.28 ± 2.44 (28.96 – 43.15)	32.60 ± 2.35 (26.69 – 37.74)	-6.75	<0.001
	<b>t = 0.83, P = 0.41</b>	<b>t = 6.96, P &lt; 0.001</b>		

*t and P values in bold print denote statistical significant levels in the right and left hand and foot of the respective sexes.*

Table 4 shows the correlation between hand length and foot length, in male and female subjects. The results showed a significant correlation between hand length and foot length with  $p < 0.001$ . Table 5 and show correlation of height to hand and foot of length in males and females subjects. The results showed a significant relationship with  $P < 0.001$ . Table 6 shows the predictive equations of height from hand and foot lengths, standard error and P values. The equations showed that height can be significantly predicted from right and left hand and foot lengths.

**Figure 4**

Table 4: Correlation between hand length and foot lengths in males and females.

	Males		Females	
	Right hand	Left hand	Right hand	Left hand
Right foot	0.56*	0.56*	0.63*	0.65*
Left foot	0.50*	0.49*	0.54*	0.54*

\*  $P < 0.0001$

**Figure 5**

Table 5: Correlation between height, hand length and foot length.

	Males n = 250	Females n = 150
Right hand length	0.53*	0.43*
Left hand length	0.55*	0.40*
Right foot length	0.58*	0.61*
Left foot length	0.61*	0.40*

\* P <0.0001

**Figure 6**

Table 6: Multiple regression analysis of height on hand and foot lengths.

Sex	n	Predictive Equations	r	r <sup>2</sup>	SE	t	p
Males	250	Ht = 61.036 + (1.579 x RHL) - (1.003 x LHL) + (3.524 x RFL) + (0.0817 x LFL)	0.61	0.38	12.18	5.013	<0.001
Females	150	Ht = 71.965 + (0.0276 x RHL) - (2.410 x LHL) + (0.268 x RFL) + (1.787 x LFL)	0.67	0.45	8.11	8.89	<0.001

Ht= Height, Wt= Weight, RHL= Right hand length, LHL= Left hand length, RFL= Right foot length, LFL= Left foot length, SE= Standard error

**DISCUSSION**

The present study strongly confirms sexual dimorphism in the hand and foot length and widths as earlier studies reported that these are larger in the males than in the females (1, 9). In hand and foot length to stature ratios we observed that females tended to have higher values than that of males. This finding is in contrast with the earlier reports of Fessler et al (11) reporting on three separate populations in South America, that the foot length to stature ratio is higher in males than females. The finding of the present study also supports the report of Baba (11) and Anil et al (13) who reported smaller ratios for males. The finding reflects that even though the both length of hand and foot is longer in the males the width is equally larger in the males therefore reducing the stature-ratio in the males.

Hand and foot indices showed a different pattern when compared to other studies. Recent study by Agnihotri et al (1) and Tyagi et al (10), showed that there was a consistent difference in the range of foot index between males and females across ages 18 – 22 and above. The present study

which was also conducted in a similar age group (19- 35 years) in Nigerians showed a slight deviation from their studies. The forensic application is that hand and foot indices > 47 and > 38 respectively will certainly denote a male Nigerian.

The relationship between hand and foot length and height is strongly significant (P<0.001). When hand and foot were correlated the relationship between hand and foot length was higher in the females than the males, but when hand and foot lengths were compared to height the relationship was stronger in the males than in the females. Multivariate analysis was conducted to see if the height of subjects could be predicted from the lengths of right and left hands and feet. This proved to be effective and provided valuable predictive equations that enable the prediction of height for both males and females, with higher prediction ability in the females than the males. This finding is in agreement with reports from Turkish sample (4, 6) and Indian sample (9, 14).

Findings from this study have implications of forensic science as well as for evolutionary biology. The results indicate that the reliability of identification of isolated foot and lower leg specimens to sex and race categories is high.

In Conclusion, the results from these study therefore, indicate that if the hand length is known, foot length can be predicted and if the foot length is known, hand length can be predicted and vice versa. The present study shows that hand and foot measurement yielded important predictive information about individual height.

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