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Research Report

Sexual Dimorphism and Stature Estimation from Hand and Foot Variables in Ondo State, Nigeria.

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Abstract – Forensic anthropology relies critically on accurate sexual differentiation and stature estimation from skeletal remains, particularly in populations with significant ethnic diversity. This study investigated hand and foot measurements among the Yoruba population in Ondo State, Nigeria, to develop population-specific anthropometric models for forensic identification and individual characterization. A comprehensive cross-sectional study was conducted with 300 participants (110 males, 190 females) aged 17-55 years. Researchers meticulously measured hand and foot dimensions, including hand length, hand breadth, wrist diameter, foot length, and foot breadth. Advanced statistical analyses were employed, encompassing independent t-tests, Pearson correlation, stepwise regression, and discriminant function analysis to explore the intricate relationships between these physical measurements, sex, and stature. Significant sexual dimorphism was observed across all hand and foot measurements ($p < 0.001$), with males consistently demonstrating larger physical dimensions. Right hand breadth (RHB), right hand length (RHL), and right foot length (RFL) emerged as the most robust sex predictors, achieving an impressive 88.7% accuracy in discriminant analysis. Stature estimation revealed that hand and foot measurements explained 37.6% of variance in males and 22.8% in females. Notably, RHB proved most significant for male stature prediction, while RFL was most predictive for females. These findings substantially enhance the anthropometric database for Nigeria, offering pragmatic forensic applications for population-specific identification. The research underscores the reliability of hand and foot measurements in sex determination and stature estimation within the Yoruba population, providing valuable insights for forensic anthropology and archaeological investigations.

Keywords: Forensic anthropology, sexual dimorphism, stature estimation, hand measurements, foot measurements, Yoruba population, Nigeria.

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Introduction

The assessment of sex and stature from osseous remains constitutes a fundamental element of forensic anthropology, yielding essential insights for the identification of individuals within both judicial and archaeological frameworks (Kamnikar *et al.* 2024). Precise estimations can facilitate the elucidation of criminal inquiries, investigations concerning missing persons, and augment our comprehension of population biology and variability (Krishan *et al.* 2016; Torimitsu & Makino 2016; Donlon 2024). In Nigeria, characterized by a complex mosaic of ethnic diversity and demographic variation (Abdullahi 2024; Agboola & Fasasi 2024; Chidozie & Orji 2024), the formulation of foundational anthropometric data specifically adapted to distinct populations is crucial. This research is centered on the appraisal of stature and sex utilizing dimensions of the hand and foot from a sample population in Ondo State, Nigeria.

Anthropometry, defined as the systematic examination of human body measurements, has served as a pivotal instrument within the domain of biological anthropology for numerous centuries (Singh & Mehta 2010; Preedy 2012; Utkualp & Ercan 2015). The association between various anthropometric dimensions and overall stature has been extensively documented, with empirical investigations across diverse populations uncovering notable correlations. These associations are particularly evident in the extremities, where the metrics of the hand and foot have demonstrated substantial potential in forecasting both sexual dimorphism and stature (Karmalkar & Nikam 2021; Kira *et al.* 2023; Yadav *et al.* 2023). The justification for employing hand and foot measurements is predicated on their straightforwardness in measurement, widespread availability, and the capacity for yielding high precision in estimations (Uhrová *et al.* 2015; Kim *et al.* 2018).

The human hand and foot are distinctive anatomical structures that serve essential functions in daily activities, showcasing both functional and evolutionary adaptations (Marzke & Marzke 2000; Fleagle 2013; Marzke 2013). The hand, characterized by its complex configuration of bones, muscles, and tendons, is optimized for precision and dexterity, facilitating intricate tasks such as grasping, object manipulation, and fine motor skills (Sobinov & Bensmaia 2021; Schelly & Dunse 2024). Similarly, the foot is uniquely adapted to support bipedal locomotion, featuring an intricate arch system that provides

stability and shock absorption during walking or running. The alignment and proportions of the foot's bones are crucial for balance and mobility, which are vital for upright movement (Hollander & Heidt 2023).

The dimensions of the hand and foot are significant in the individuation process, particularly within the disciplines of biological anthropology and forensic science (Mohamadon *et al.* 2018; Gupta *et al.* 2022; Suleiman *et al.* 2024). These measurements are valuable due to their associations with sex (Iroanya *et al.* 2020) and stature (Moustafa 2017), their uniqueness as identifiers (Adjei-Antwi *et al.* 2023; Hassanain *et al.* 2023), their cultural relevance (Bimpong *et al.* 2023), and their practical measurement capabilities (Senol *et al.* 2023). Additionally, they offer insights into functional adaptations (Dickinson *et al.* 2023; Sorrentino *et al.* 2023) and can reflect environmental influences and personal habits (Mohamadon *et al.* 2018; Mihalache 2023), thereby enriching the narrative of an individual's life story.

In the Nigeria context, anthropometric data are sometimes generalized or sourced from populations that may not accurately reflect the local demographic characteristics. This deficiency in specificity has the potential to result in inaccuracies in forensic applications, underscoring the necessity for studies that are tailored to specific regions. Ondo State, located in the southwestern part of Nigeria, is distinguished by a distinctive amalgamation of cultural practices and genetic heritages (Omotosho *et al.* 2020), thereby rendering it a significant population for anthropological inquiry. By concentrating on this particular region, the research aspires to enhance the wider discipline of forensic anthropology by offering dependable models for the estimation of sex and stature that are relevant to the population of Ondo State in Nigeria.

This research possesses considerable importance that transcends mere academic inquiry, providing tangible applications within forensic investigations while simultaneously advancing our comprehension of human diversity in Nigeria. In forensic contexts that entail skeletal remains, the capacity to ascertain sex and estimate stature can substantially refine identity searches, thereby assisting law enforcement agencies in cases pertaining to unidentified corpses or mass burial sites. The models that have been developed are designed to enhance the precision of estimations, ultimately augmenting the quality of forensic practice within Nigeria. Through the documentation of the anthropometric features of the Ondo State populace, this research offers an invaluable reference framework for subsequent comparative analyses, both domestically and on an international scale. Furthermore, the study bears wider implications for public health,

ergonomics, and sports science, potentially guiding targeted health interventions, the design of equipment, and the optimization of athletic performance. Ultimately, this research lays a foundational groundwork for prospective studies aimed at enhancing the quality of life and health outcomes within the community.

Materials and Methods

Study Design and Ethical Considerations

This cross-sectional study was executed at the University of Medical Sciences located in Ondo State, Nigeria (**Fig. 1**). Prior to the initiation of the research, ethical clearance was secured from the Research Ethics Committee of the University of Medical Sciences. Comprehensive information regarding the aims and methodologies of the study was disseminated to all participants, and written informed consent was procured from each individual prior to the collection of any data.

Study Population and Sampling

The study cohort consisted of individuals who are either students or personnel affiliated with the University of Medical Sciences, specifically those of Yoruba descent (**Fig. 2**). An individual was classified as being of Yoruba descent if both progenitors, extending to the second filial generation, were identified as Yoruba. A total of 300 participants (comprising 110 males and 190 females) aged between 17 and 55 years were enlisted for the research. Individuals who exhibit physical deformities or injuries that impact the measurements of the hands, feet, or arms, those with a history of orthopedic surgeries or conditions that modify standard body proportions, or those who are pregnant (in the case of female participants) were excluded from the study.

Anthropometric Measurements

All measurements were obtained in accordance with established protocols to guarantee uniformity and precision. Measurements were conducted on the right side of the body, as this side is conventionally regarded as more indicative of actual body dimensions owing to the predominance of right-handedness within the majority of populations (Krishan *et al.* 2016). The subsequent variables were assessed:

1. Height (H): Assessed utilizing a stature meter, with the participant positioned barefoot in the Frankfurt horizontal plane posture.

Fig. 1: Map of Nigeria showing Ondo state (Fagbemi *et al*. 2020).

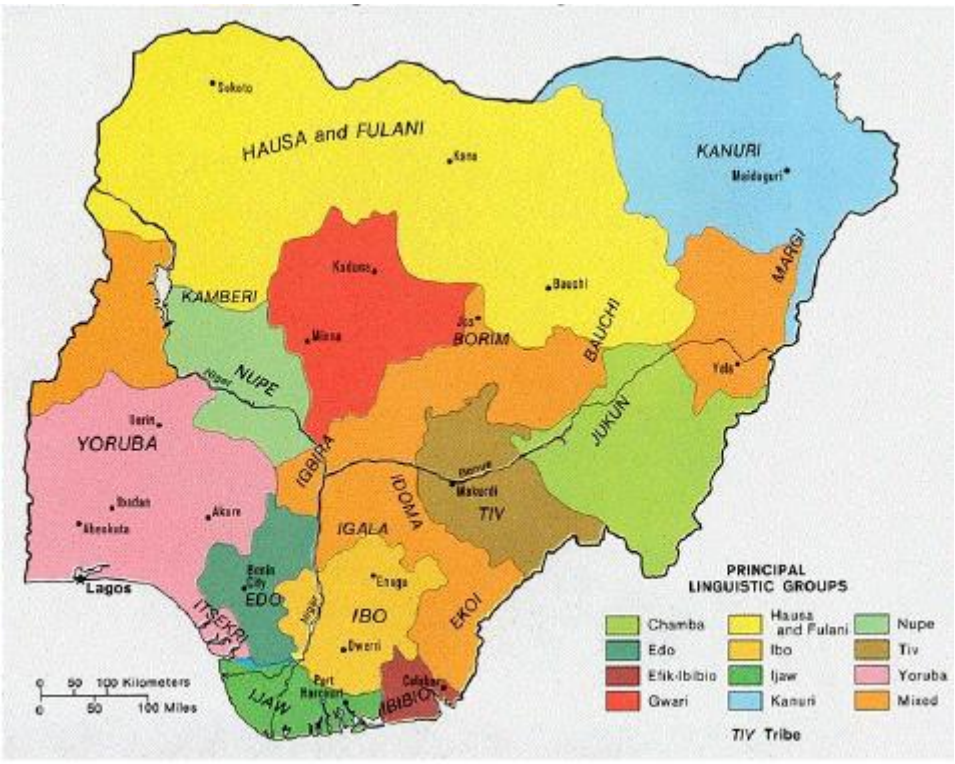

Fig. 2: Map of Nigeria highlighting the major ethnic groups (Bakare 2015).

2. Right Hand Length (RHL): Determined from the midpoint of the distal transverse crease of the wrist to the tip of the middle finger, with the hand fully extended and the palm oriented upwards.

3. Right Hand Breadth (RHB): Gauged across the palm at the level of the metacarpal heads, extending from the lateral aspect of the second metacarpal to the medial aspect of the fifth metacarpal.

4. Right Hand Wrist Diameter (RHWD): Quantified as the measurement between the styloid processes of the radius and ulna.

5. Right Foot Length (RFL): Measured from the most posterior point of the heel to the tip of the longest toe (typically the first or second toe), with the participant in a standing position.

6. Right Foot Breadth (RFB): Assessed across the broadest section of the foot, generally at the level of the metatarsal heads.

7. Right Arm Diameter (RAD): Measured at the midpoint between the acromion process and the olecranon process, with the arm in a relaxed position at the side.

All linear measurements were taken using digital vernier calipers (Microtech 2015) with a precision of 0.01 mm. Height was measured to the nearest 0.1 cm using a stature meter. Diameter measurements were taken with a non-stretchable anthropometric tape. Each measurement was performed twice, and the average was recorded. If the discrepancy between the two measurements exceeded 4 mm, a third measurement was taken, and the average of the two closest measurements was used.

Data Collection and Management

A standardized form was employed to document demographic details and anthropometric measurements for each participant. The collected data were subsequently entered into a secure, password-protected database. To maintain data integrity, 10% of the entries were randomly selected and verified against the original forms for accuracy.

Statistical Analysis

Statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including means, standard deviations, and ranges, were computed for all variables, disaggregated by sex.

Independent t-tests were utilized to compare the mean values of anthropometric measurements between males and females. Pearson's correlation coefficients were calculated to explore the relationships between hand and foot dimensions and stature.

Stepwise regression was used to identify the most significant predictors of stature based on hand and foot dimensions.

For sex determination, linear discriminant function analysis was conducted with hand and foot dimensions as independent variables. The accuracy of sex classification was evaluated using cross-validation techniques (leave-one out Cross validation).

A p-value of <0.05 was considered statistically significant for all analyses.

Results

Table 1: Descriptive and inferential statistics of hand and foot dimensions of the study participants.

Variables	Sex	N	Mean±SD	t	df	p-value	Inf.
HEIGHT(cm)	M	110	176.942±7.51	14.188	298	0.000	Sig
	F	190	165.402±6.33				
RHL (cm)	M	110	21.618±1.41	10.469	298	0.000	Sig
	F	190	20.014±1.20				
RHB (cm)	M	110	8.52±0.54	16.121	298	0.000	Sig
	F	190	7.70±0.34				
RHWD (cm)	M	110	17.802±1.00	10.099	298	0.000	Sig
	F	190	16.507±1.11				
RFL (cm)	M	110	27.298±2.10	8.696	298	0.000	Sig
	F	190	25.434±1.60				
RFB (mm)	M	110	95.788±10.38	9.396	298	0.000	Sig
	F	190	86.956±5.91				
RAD (cm)	M	110	23.898±5.60	4.432	298	0.000	Sig
	F	190	21.906±2.03				

M = male, F= female, N = number of participants, SD= standard deviation, t=t-test statistic, df =degree of freedom, sig = significance value, inf.= inference. RHL=Right hand length, RHB=Right hand breadth, RHWD=Right hand wrist diameter, RFL=Right foot length, RFB=Right foot breadth and RAD=Right arm diameter.

T-test analysis reveals that there are statically significant differences in the mean values of height and the various hand and foot dimensions amongst male and female participants of the study. The analysis showed that the males had higher values when compared to the females. Height [$t(298)$ =14.18, P <0.001], RHL[$t(298)$=10.47, P <0.001], RHB[$t(298)$=16.12, P <0.001], RHWD[$t(298)$=10.10, P <0.001], RFL[$t(298)$=8.70, P <0.001], RFB[$t(298)$=9.40, P <0.001] and RAD[$t(298)$=4.43, P <0.001].

Correlation

Table 2: Correlations between height and hand and foot dimensions in study participants

Variables		H (cm)	RHL (cm)	RHB (cm)	RHWD (cm)	RFL (cm)	RFB (cm)	RAD (cm)
H (cm) Males (N =110)	*r*	1	0.401**	0.537**	0.375**	0.359**	0.310**	0.053
	p		0.000	0.000	0.000	0.000	0.001	0.583
H (cm) Females (N=190)	*r*	1	0.345**	0.298**	0.110	0.395**	0.232**	0.056
	p		0.000	0.000	0.132	0.000	0.001	0.443

r = Pearson's correlation statistics, N = number of participants, p = p-value, RHL=Right hand length, RHB=Right hand breadth, RHWD=Right hand wrist diameter, RFL=Right foot length, RFB=Right foot breadth and RAD=Right arm diameter.

The results of Pearson's correlation between height and the studied variables for the male participants reveals significant positive strong correlation with right hand breadth [r=0.54, p =0.000]. Positive significant correlations were also observed with right hand wrist diameter [r(109)=0.38, p<0.001], right hand length [r(109)=0.40, p<0.001], right foot length [r(109)=0.36, p<0.001], right foot breadth [r(109)=0.31, p = 0.01]. The right arm diameter exhibited negative non-significant correlation with height [r(109)= -0.053, p =-0.583]. The results of the correlation analysis between height and the studied variables for the female participants reveals significant positive correlations with right hand length [r(189)=0.35, p<0.001], right hand breadth [r(189)=0.29, p<0.001], right foot length [r(189)=-0.395, p<0.001] and right foot breadth [r(189)=0.23, p<0.001]

Table 3: Stepwise regression analysis of hands and feet variables for stature estimation for the male participants

variables	Model summary			Model significance		Model coefficients			
	R	R^2	Adjusted R^2	F	F (p-value)	UC	SC	t	p-value
	0.613	0.376	0.358	21.257	0.000				
K						84.521	-	7.168	0.000
RHB(mm)						0.569	0.118	4.819	0.000
RFL (cm)						0.764	0.287	2.657	0.009
RHL (cm)						1.067	0.445	2.396	0.018

UC = unstandardized coefficients, SC= standardized coefficients, k= constant, RHB = right hand breadth, RFL = right foot length, RHL, RHL = right hand length. F = ANOVA statistics, t = t-test for model coefficients. (Method =Wilks' Lambda)

The stepwise regression analysis for the estimation of stature for the male participants shows that the model variables has an R value of 0.613, indicating a moderate positive correlation. The R square value is 0.376, meaning 37.6% of the variance in stature is

explained by the variables. The results shows that the model is statistically significant ($p < 0.001$), with RHB, RFL, and RHL all contributing positively to the estimation of stature. The resulting regression equations for the estimation of stature is: Stature = 84.521 + 0.569(RHB) + 0.764(RFL) + 1.067(RHL). The model demonstrates that demonstrate the combinations of hand and foot measurements can be used to estimate stature in the male cohort.

Table 4: Stepwise regression analysis of hands and feet variables for stature estimation for the female participants

variables	Model summary			Model significance		Model coefficients			
	R	R^2	Adjusted R^2	F	F (p-value)	UC	SC	t	p-value
	0.478	0.228	0.220	27.651	0.000				
K						101.988	-		
RFL (cm)						1.348	0.338	5.146	0.000
RHL (cm)						1.456	0.275	4.185	0.000

UC = unstandardized coefficients, SC= standardized coefficients, k= constant, RHB = right hand breadth, RFL = right foot length, RHL, RHL = right hand length. F = ANOVA statistics, t = t-test for model coefficients. (Method =Wilks' Lambda)

The stepwise regression analysis for the estimation of stature for the female participants shows that the model variables has an R value of 0.478, indicating a moderate positive correlation. The R square value is 0.228, meaning 22.8% of the variance in stature is explained by the variables. The results shows that the model is statistically significant ($p < 0.001$), with RFL, and RHL all contributing positively to the estimation of stature.
The resulting regression equations for the estimation of stature is: Stature = 101.988 + 1.348(RFL) + 1.456(RHL). The model demonstrates that demonstrate the combinations of hand and foot measurements can be used to estimate stature in the female cohort.

Sex estimation

Table 5a; Variables contributing to the stepwise discriminant function analysis

Step	Entered	Wilks' Lambda							
		Statistic	df1	df2	df3	Exact F			
						Statistic	df1	df2	p-value
1	RHB (mm)	0.534	1	1	298.000	259.894	1	298.000	0.000
2	RHL (cm)	0.514	2	1	298.000	140.660	2	297.000	0.000
3	RFL (cm)	0.499	3	1	298.000	99.076	3	296.000	0.000

Maximum F to enter is 2.71 and Minimum F to enter is 3.84

Variables contributing to the stepwise discriminant function analysis of hand and foot dimensions for sex estimation. The discriminant function model evaluates three key variables: Right Hand Breadth (RHB), Right Hand Length (RHL), and Right Foot Length (RFL). The table provides Wilks' Lambda, Exact F-statistic, and significance levels for each step, demonstrating the contribution of each variable.

The stepwise discriminant function analysis reveals that the RHB (Right Hand Breadth) was the first variable entered into the model, with the lowest Wilks' Lambda (0.534) and a highly significant F-statistic ($F=259.894$, $p<.001$). Subsequently, RHL and RFL were introduced, reducing Wilks' Lambda further and maintaining high statistical significance ($p<.001$). These results suggest that hand and foot dimensions, particularly breadth and length, are strong predictors of sex.

Table **5b**: Discriminant function analysis for hands and feet variables

	SCDFC	**UCDFC**	**EV**	**CC**	**WL**	**CSP**
Variables		Function				
RHL (cm)	0.263	0.205	1.004	0.708	0.499	0.000
RHB (cm)	0.768	0.182				
RFL (cm)	0.249	0.139				
Constant	-	-22.388				

SCDFC = Standardized Canonical Discriminant Function Coefficients, UCDFC = Unstandardized Canonical Discriminant Function Coefficients, EV = Eigen value, CC= canonical correlation, WL = Wilks'Lambda, CSP = chi square p-value, RHB = right hand breadth, RFL = right foot length, RHL = right hand length

Standardized and unstandardized canonical discriminant function coefficients for hands and feet variables in sex estimation. The table presents eigenvalue, canonical correlation, and Wilks' Lambda, showing the overall strength of the discriminant function and statistical significance.

The standardized coefficients highlight RHB (Right Hand Breadth) as the strongest contributor (SCDFC = 0.768) to the discriminant function, followed by RHL and RFL with lower coefficients. The eigenvalue (1.004) and canonical correlation (0.708) indicate a strong relationship between the discriminant function and sex. The Wilks' Lambda value of 0.499, with a chi-square test showing high statistical significance ($p<.001$), underscores the model's ability to discriminate between male and female groups.

Table 5c: Functions at the group centroids depicting average discriminant scores in males and females

Sex	Function	Sectioning point
	1	
Male	1.313	0.2765
Female	-.760	

Unstandardized canonical discriminant functions evaluated at group means
The discriminant scores at group centroids are positive for males (1.313) and negative for females (-0.760), with a sectioning point at 0.2765. a score above the sectioning point is most likely to be male and vice versa.

Table 5d: Classification accuracy of the functions in stepwise discriminant function analysis

		Sex	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	91	19	110
		Female	15	175	190
	%	Male	82.7	17.3	100.0
		Female	7.9	92.1	100.0
Cross-validated[b]	Count	Male	89	21	110
		Female	17	173	190
	%	Male	80.9	19.1	100.0
		Female	8.9	91.1	100.0

88.7% of original grouped cases correctly classified.
87.3% of cross-validated grouped cases correctly classified.

The discriminant function shows high accuracy in predicting sex, with 88.7% of original grouped cases and 87.3% of cross-validated cases correctly classified. Males are accurately classified 82.7% of the time, while females are classified with 92.1% accuracy in the original analysis. Cross-validation results remain strong, with 80.9% accuracy for males and 91.1% for females, demonstrating the robustness of the discriminant model in distinguishing between sexes using hand and foot measurements.

Discussion

This research examined the efficacy of utilizing hand and foot dimensions to infer sex and stature within a cohort from Ondo State, Nigeria. The results indicate significant sexual dimorphism across all assessed variables and underscore the applicability of these anthropometric measurements for forensic and anthropological purposes.

The research identified statistically significant variances between male and female subjects across all assessed variables ($p < 0.001$), with male subjects consistently exhibiting larger dimensions. This observed sexual dimorphism aligns with conclusions drawn from diverse global populations (Fessler *et al.* 2005; Case & Rose 2007; Krishan *et al.* 2011; Jee *et al.* 2015). The application of discriminant function analysis indicated that a composite of right-hand breadth (RHB), right hand length (RHL), and right foot length (RFL) could effectively classify biological sex in 88.7% of instances (87.3% during cross-validation). This elevated accuracy rate is comparable to or surpasses those documented in analogous research endeavors (Mastrangelo *et al.* 2011; Lalwani *et al.* 2019; Bidmos *et al.* 2020; Maalman *et al.* 2021), implying that measurements of the hands and feet serve as reliable indicators of biological sex within the population of Ondo State.

The discriminant function analysis indicated that right hand breadth (RHB) serves as the most significant predictor of biological sex, succeeded by right hand length (RHL) and right foot length (RFL). This observation is consistent with research conducted on various populations that have similarly acknowledged hand breadth as a salient discriminator of sex. Such studies encompass a wide array of populations, including Sudanese adults (Ahmed 2013), South Koreans (Jee *et al.* 2015), Egyptian and Malaysian youths (Hafez & Shahin 2021), adult Tanzanians (Zahor & Russa 2022), South Indians (Kumar & Karthikeyan 2023), inhabitants of the Delhi region in India (Rahman *et al.* 2023), and the Ebiras of Kogi State, Nigeria (Suleiman *et al.* 2024). The significance of hand measurements in the estimation of sex may be elucidated by the impact of sex hormones on skeletal growth and muscular development, particularly within the upper extremities (Banyeh *et al.* 2023).

Our analysis utilizing discriminant function demonstrated a marginally superior accuracy in categorizing female subjects (92.1%) in contrast to male subjects (82.7%), a noteworthy observation that necessitates additional scrutiny. We propose that this observed variation may be attributable to increased variability in the dimensions of male

hands and feet, potentially influenced by factors such as occupational disparities or variations in physical activity levels. Notwithstanding this variability, it is evident that males, as a general trend, exhibit larger dimensions in both hands and feet compared to females. Researchers attribute these dimensional discrepancies to an interplay of various factors, including the developmental impacts of sex hormones and inherent genetic tendencies (Kurrey *et al.* 2017; Das *et al.* 2024). The reliability and significance of these dimensional differences across diverse populations underscore the utility of hand and foot measurements as instrumental resources for applications in forensic science and personal identification.

The investigation elucidated that the measurements of the hands and feet could serve as reliable indicators for estimating stature with a moderate degree of accuracy. In male subjects, the combination of right-hand breadth (RHB), right foot length (RFL), and right hand length (RHL) accounted for 37.6% of the variance in stature, whereas in female subjects, the combination of RFL and RHL elucidated 22.8% of the variance. Although these findings are statistically significant, they imply that additional unmeasured factors also play a substantial role in the variability of stature.

The pronounced correlation between hand and foot measurements and stature in male participants (R = 0.613) as opposed to female participants (R = 0.478) aligns with observations derived from various populations, including the Turkish population (Parlak *et al.* 2024), the North Indian population (Mishra *et al.* 2023), the Punjab population of Pakistan (Asghar *et al.* 2021), the South Indian population (Karthi *et al.* 2022), the Maharashtrian population (Methepatil & Dethe 2022), the Bangladeshi population (Asadujjaman *et al.* 2019), the Korean population (Kim *et al.* 2018), and Slovak adults (Uhrová *et al.* 2015). This observed sexual dimorphism in the strength of correlation may be ascribed to the more pronounced genetic and environmental factors influencing male growth patterns (Isen *et al.* 2014).

Interestingly, the research indicated that distinct combinations of variables were optimal for stature estimation in male and female subjects. In male participants, hand breadth emerged as a pivotal predictor in conjunction with hand and foot lengths, while in female participants, only the length measurements proved to be significant. This observation advocates for the application of sex-specific equations to achieve optimal stature estimation, a recommendation substantiated by other scholars in the discipline (Uhrová *et al.* 2015; Saco-Ledo *et al.* 2020; Kamnikar *et al.* 2024).

Table **6**: Summary of Studies on Sex and Stature Estimation from Hand and Foot Dimensions in Nigerian Populations

Author	**Ethnic Group**	**Geographic Location**	**Conclusion**
Danborno & Elukpo 2008	Selected Nigerian undergraduate students	Ahmadu Bello University, Zaria, Kaduna State	Hand and foot dimensions significantly predict sex and height, with males typically having larger measurements.
Ogugua *et al*. 2012	Igbo	Ebonyi State	Stature can be reliably estimated from foot dimensions in Nigeria, with foot circumference being more reliable for males and foot length being more reliable for females.
Jervas *et al.* 2014	Igbo	Imo State, Nigeria	Palm length provided a precise means of stature estimation. The second digit was the most accurate for estimating stature in males, but combining the second and third digits in multiple regression analysis yielded even better results.
Oria *et al.* 2016	Efik, Ibibio, Ikom, Ogoja, Obubra, Boki, Yala, Obudu	Cross Rivers State	Hand length is a reliable estimator of stature in both males and females.
Oladipo *et al.* 2017	Annang	Akwa Ibom State	The study indicates that there are sexual dimorphism in hand and foot dimensions. It also highlights the potential to accurately estimate stature based on the right foot length, as well as the lengths of the right second and fourth digits.
Oladipo *et al.* 2018	Igbo	Rivers State	Hand length, hand breadth, palm length and palm width of the right and left hands were able to discriminate sex in the population with an accuracy of 70.5%.
Igbigbi *et al.* 2018	Delta Igbo and Isoko	Delta State	Stature can be accurately estimated from hand and foot dimensions, with hand breadth being a significant predictor of stature in the study population
Ikpa *et al.* 2019	Nigerian undergraduate students	University of Lagos, Nigeria	Discriminant function analysis successfully classified sex based on foot dimensions with an accuracy of 92.3%.
Iroanya *et al*. 2020	Nigerian undergraduate students	University of Lagos, Nigeria	Variables of the hand (length and breadth), the index/ring finger ratio, foot (length and breadth), and ankle breadth are crucial indicators for predicting sexual dimorphism and for identifying human remains in forensic and medicolegal contexts.
Bafor *et al*. 2023	Benin	Edo State	Foot length is a reliable indicator for estimating the height of school-aged Nigerian children. This makes it a valuable tool in forensic medicine and for height estimation when direct measurement isn't feasible.

This study, conducted in Ondo State, Nigeria, reveals a high degree of precision for the estimation of biological sex and a moderate degree of precision for the estimation of

stature, thereby providing essential instruments for the discipline of forensic anthropology. These methodologies prove to be especially advantageous in the identification of individuals from fragmented remains, particularly in instances where standard skeletal elements are not accessible. The findings of this research significantly augment Nigeria's population-specific anthropometric database, which is crucial for accurate forensic evaluations in light of the country's ethnic heterogeneity (Agboola & Fasasi 2024). Additionally, this information enhances the comprehension of patterns of human variation within the Nigerian context. The implications of these findings are substantial for forensic practices in the region and serve to broaden the knowledge base within the field.

Conclusion

This investigation conducted in Ondo State, Nigeria, elucidates the efficacy of hand and foot metrics in the estimation of biological sex (with an accuracy rate of 88.7%) and stature (exhibiting moderate accuracy) within the domain of forensic anthropology. This research endeavor enriches the body of population-specific anthropometric data pertinent to Nigeria, thereby addressing a significant gap in this ethnically heterogeneous nation. The observed manifestations of sexual dimorphism, alongside the differing correlations between hand and foot dimensions and stature, underscore the critical necessity for sex-specific methodologies.

The implications of these findings are profound for forensic practices in Nigeria, as they possess the potential to significantly assist in criminal investigations and the identification of victims in disaster scenarios. Furthermore, they contribute to a deeper comprehension of human variation within Nigeria, which holds broader ramifications for anthropological studies.

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Conflict of Interest Statement

The authors declare no conflict of interest in relation to this study.

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