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Short Research Report

Bilateral hand and digit lengths for stature estimation: A study of Isoko ethnic student populations in Nigeria.

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Abstract - The relationship between hand anthropometry and stature has been a subject of interest in anthropometric studies, particularly in understanding biological profiles across different populations. This study aimed to investigate the correlation between bilateral hand and finger measurements and stature among Isoko undergraduate students at Southern Delta University, to develop tailored stature-prediction equations for this population. A descriptive cross-sectional research design was employed, involving 180 participants (90 males and 90 females) aged 18 to 25 years. Ethical approval was obtained, and data were collected on participants' biological profiles, including age and sex, as well as hand and finger lengths and stature, using standardized measurement techniques. Data analysis was conducted using SPSS version 23.0, employing descriptive and inferential statistics, including t-tests and linear regression analyses. The study revealed that males had a mean stature of 173.32 cm, significantly higher than the female average of 162.80 cm. Additionally, males exhibited longer hand lengths (HL), with right (R-) and left (L-) hands averaging 20.21 cm and 19.93 cm, respectively, compared to females' averages of 19.20 cm and 19.05 cm. All index (IFL), middle (MFL), and ring (RFL) lengths significantly differed between sexes. For both males and females, regression equations for determining stature (S) using HL, IFL, MFL, and RFL were deduced and found to be statistically significant. Conclusively, the linear regression equations deduced provide a framework for estimating stature based on bilateral hand and finger measurements for both males and females in the Isoko population, thereby highlighting the importance of considering ethnic factors and bilaterality in anthropometric research.

Keywords: Bilaterality, Hand dimensions, Stature, Isoko ethnic group, Prediction equations, Forensic anthropology

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Introduction

Estimating the stature of a person is a cornerstone of forensic anthropology because it helps build a full biological profile for unidentified skeletal remains (Sanli *et al*. 2005; Austin & King 2016). This information is especially vital in legal-medical investigations where bodies are fragmented, decomposed, or wholly skeletonized, and other circumstances that frequently arise in criminal cases or mass-disaster events, and where traditional identification methods often fail (Krishan & Sharma 2007; Kanchan & Rastogi 2009). Stature estimation rests on the well-documented proportional relationships between total height and the lengths of selected body segments such as hands, legs, fingers, and toes (Jasuja & Singh 2004; Uhrová *et al*. 2015; Ruff *et al*. 2019; Hughes *et al*. 2021; Shreeya & Chandran 2021). Although measurements of long bones are preferred because they yield the smallest prediction error (Krishan *et al*. 2010; Duyar *et al*. 2018), forensic practitioners sometimes must rely on peripheral elements when the more reliable long bones are missing or damaged (Jankova 2024; Hussein & Mohamed 2025).

Hand dimensions such as hand length and the lengths of individual fingers have repeatedly shown strong, statistically significant correlations with stature across a wide range of populations (Ozaslan *et al*. 2006; Asadujjaman *et al*. 2019; Mahmood *et al*. 2025). Phalangeal measurements are especially useful in forensic contexts because they can be obtained non-invasively and often survive when larger bones are absent (Rastogi *et al*. 2009; Venkatesan *et al*. 2024). Moreover, these hand metrics display pronounced sexual dimorphism globally, further reinforcing their value as indicators of overall body size (Karakostis *et al*. 2013; Alabi *et al*. 2020; Srinivasulu *et al*. 2022; Yegbeburu *et al*. 2022). A key tenet of forensic anthropometry is that predictive models must be tailored to specific populations. Linear regression equations are heavily influenced by the unique skeletal and somatic proportions of each ethnic group and cannot be universally applied (Numan *et al*. 2013; Ozaslan *et al*. 2014). These proportional differences arise from a complex mix of genetic background, environmental influences, and historical demographic patterns. Within Nigerian groups, the second and fourth fingers have emerged as the most reliable predictors of height (Numan *et al*. 2013; Alabi *et al*. 2020; Dhulqarnain *et al*. 2025). Consequently, the

creation of ethnicity-specific equations is essential for maximizing accuracy and reducing error in forensic height estimations.

The Isoko people are a small, ethnically distinct community residing primarily in the Niger Delta region of southern Nigeria (Okperva 2020). Over the years, they have been largely overlooked in anthropometric research because they make up a key minority of the tribes within the region. A comprehensive review of height-prediction studies using bilateral hand anthropometrics conducted on Nigerian samples reveals a conspicuous lack of data pertaining to the Isoko population. Despite the consistent efforts of scholars advocating for population-specific approaches, no scientific investigations have yet examined biometric correlations such as bilateral hand and finger lengths versus stature for the Isoko ethnic population. The present study, therefore, aimed to fill this gap for the specific population by developing stature-prediction equations based on the application of bilateral hand and finger measurements.

Materials and Methods

Research Design

This study adopts a descriptive cross-sectional research design. The study was conducted among undergraduate students of Isoko ethnicity of the Faculty of Basic Medical Sciences, Southern Delta University, Ozoro Campus, Delta State, Nigeria. The university is situated in the semi-urban community of Ozoro in South-South Nigeria that comprises mainly residents of the Isoko ethnicity (see Fig. 1). Participants included students aged 18 to 25 years from the Departments of Human Anatomy and Human Physiology within the faculty. Some of the inclusion criteria used for selection of participants included: all subjects were in the age range of 18 – 25 years, devoid of hand deformities, injuries, or medical conditions affecting limb measurements, and were of Isoko ethnicity. After obtaining ethical approval from the Southern Delta University Research Ethics Committee, both primary and secondary data were obtained from these subjects. Biological profiles such as age and sex represented the primary data, while measurements such as hand and finger lengths, as well as height, were the secondary data.

Sample Size Determination

In this study, the estimated sample size was calculated using the Taro-Yamane formula (Adam 2020).

$$n = \frac{N}{1 + Ne^2}$$

where: n = required sample size, N = total population size, and e = margin of error (0.05 for 5%)

In this study, the total sample population (N) comprising Isoko undergraduate students of the Faculty of Basic Medical Sciences of Southern Delta University was 330.

Therefore, the sample size (n) was calculated as

$$n = \frac{330}{1 + 330 \times 0.05^2} = 180.82$$

Upon the utilization of Taro Yamane's formula for sample size determination, an approximate total of 180 participants were targeted. Participants were selected through stratified random sampling to ensure a total proportion of 90 males and 90 females.

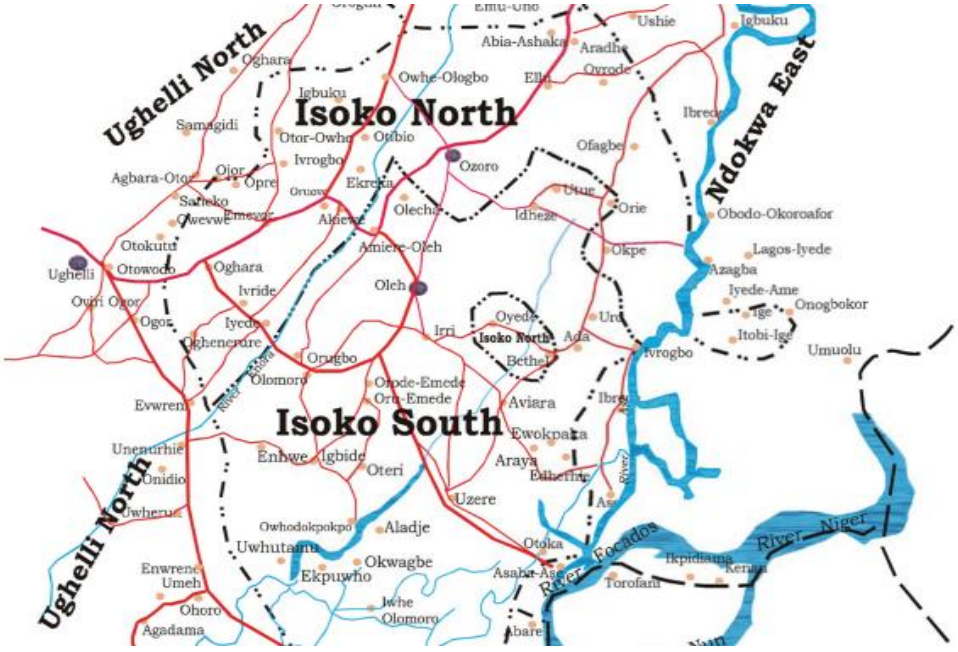

Fig. 1: Map of Isoko showing the communities in Isoko North and South local government areas (Okperva 2020).

Method of Data Collection

In line with a Bangladeshi study done by Asadujjaman *et al*. 2019 and Mohamed *et al*. 2020, the linear measurements obtained from subjects in the present study were as follows.

- Stature (Body Height): Stature is defined as the height of the individual. It is measured from the crown of the head to the sole using a stadiometer.

- Hand Length: The distance from the midpoint of the distal transverse wrist crease to the most anterior projection of the skin of the middle finger.
- Index Finger Length: The distance from the tip of the index finger to the border crease adjacent to the palm.
- Middle Finger Length: The distance from the tip of the middle finger to the border crease where the finger joins the palm.
- Ring Finger Length: The distance from the tip of the ring finger to the border crease where the finger joins the palm.

All hand anthropometrics were obtained using a metre rule (in centimetres). To test the reliability of the instruments, each variable was measured on both the right and left hands to the nearest centimetre and taken twice. The average of the two was recorded.

Statistical Analysis:

Data obtained from this study were analysed both descriptively and inferentially using Statistical Package for Social Sciences (SPSS) version 23.0. The descriptive statistics of stature and hand anthropometric variables were expressed for both genders. A student's t-test was used to evaluate gender differences between stature and hand anthropometric measurements. Linear multiple regression analyses were applied to examine the relationship between stature and bilateral hand anthropometric measurements for each gender. A statistical significance level of 0.05 was accepted.

Results

The results from Table **1** clearly displayed the descriptive statistics of Isoko subjects with respect to stature, hand and finger lengths across genders. For males (n = 90), the mean stature of 173.32 cm was higher than the female average of 162.80 cm. Based on the hand length data obtained in this study, males had slightly longer right and left hands (averaging 20.21 cm and 19.93 cm, respectively), nearly 1 cm longer than the females (19.20 cm and 19.05 cm, respectively). Considering the finger length data, males' right and left index fingers averaged 7.38 cm and 7.20 cm, respectively, compared to 6.68 cm and 6.57 cm for females. Similar patterns were also observed for both middle and ring fingers, as males had longer mean lengths than females.

Table **1:** Descriptive Statistics of Stature and Hand Parameters of Isoko subjects

Parameters	Male [n=90]				Female [n=90]			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Stature (S) (cm)	173.32	8.41	151.00	192.00	162.80	5.25	151.00	171.50
Right Hand Length (R-HL) (cm)	20.21	1.37	17.50	23.60	19.20	1.03	17.20	21.30
Left Hand Length (L-HL) (cm)	19.93	1.34	17.00	23.10	19.05	1.07	17.20	21.50
Right Index Finger Length (R-IFL) (cm)	7.38	0.49	6.37	8.39	6.68	0.37	5.78	7.56
Left Index Finger Length (L-IFL) (cm)	7.20	0.49	6.19	8.27	6.57	0.38	5.55	7.33
Right Middle Finger Length (R-MFL) (cm)	8.27	0.52	7.03	9.65	7.55	0.38	6.80	8.30
Left Middle Finger Length (L-MFL) (cm)	8.10	0.53	6.92	9.51	7.48	0.38	6.78	8.16
Right Ring Finger Length (R-RFL) (cm)	7.66	0.47	6.36	8.93	7.07	0.50	6.02	9.93
Left Ring Finger Length (L-RFL) (cm)	7.47	0.45	6.24	8.81	6.96	0.40	6.29	7.81

SD = standard deviation, Min = Minimum, Max = Maximum

In Table **2**, the results displayed the mean differences between hand parameters for each side among subjects per gender. It was observed that in all parameters, there was a highly significant difference observed across both genders ($p < 0.05$). For the male category, there was a mean difference of 0.286 ($p = <0.001$) between the right and left HL. There was a mean difference of 0.179 ($p = <0.001$) between the right and left IFL. There was a mean difference of 0.173 ($p = <0.001$) between the right and left MFL. There was a mean difference of 0.191 ($p = <0.001$) between the right and left RFL. For the female category, there was a mean difference of 0.153 ($p = <0.001$) between the right and left HL. There was a mean difference of 0.111 ($p = <0.001$) between the right and left IFL. There was a mean difference of 0.072 ($p = <0.001$) between the right and left MFL. There was a mean difference of 0.117 ($p = 0.006$) between the right and left RFL

Table 2. T-Test of Mean Differences between Bilateral Hand Parameters among Isoko subjects per gender

Parameters	Male [n=90]			Female [n=90]		
	Mean	SEM	p-value	Mean	SEM	p-value
Hand Length (HL) cm	0.286	0.025	<0.001	0.153	0.026	<0.001
Index Finger Length (IFL) cm	0.179	0.005	<0.001	0.111	0.016	<0.001
Middle Finger Length (MFL) cm	0.173	0.006	<0.001	0.072	0.018	<0.001
Ring Finger Length (RFL) cm	0.191	0.013	<0.001	0.117	0.041	0.006

SEE = Standard Error of Estimate, p-value less than 0.05 is considered statistically significant

Table 3. T-Test of Gender Differences between Bilateral Hand Parameters among Isoko subjects

Parameter	MD	SEM	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
Right HL (cm)	1.009	0.173	0.666	1.352	5.837	89	<0.001
Left HL (cm)	0.877	0.176	0.527	1.226	4.985	89	<0.001
Right IFL (cm)	0.695	0.066	0.564	0.827	10.486	89	<0.001
Left IFL (cm)	0.628	0.068	0.493	0.762	9.288	89	<0.001
Right MFL (cm)	0.715	0.065	0.586	0.843	11.043	89	<0.001
Left MFL (cm)	0.614	0.068	0.479	0.748	9.076	89	<0.001
Right RFL (cm)	0.589	0.078	0.434	0.745	7.539	89	<0.001
Left RFL (cm)	0.516	0.064	0.389	0.643	8.073	89	<0.001

HL = Hand length, IFL = Index Finger Length, MFL = Middle Finger Length, RFL = Ring Finger Length, MD = Mean Difference, SEE = Standard Error of Estimate, df = degree of freedom, Sig. = Statistical significance at $p < 0.05$

In Table 3, the results displayed the gender differences between hand parameters for each side. It was observed that in all parameters, there was a highly significant difference between genders (p = <0.001). The right HL between both genders had a mean difference of 1.009 with a standard deviation of 1.640 and a standard error of the mean of 0.173. The left HL between both genders had a mean difference of 0.877 with a standard deviation of 1.669 and a standard error of the mean of 0.176. The right IFL between both genders had a mean difference of 0.695 with a standard deviation of 0.629 and a standard error of mean of 0.066. The right IFL between both genders had a mean difference of 0.695 with a standard deviation of 0.629 and a standard error of the mean of 0.066. The left IFL between both genders had a mean difference of 0.628 with a standard deviation of 0.641 and a standard error of the mean of 0.068. The right MFL between both genders had a mean difference of 0.715 with a standard deviation of 0.614 and a standard error of the mean of 0.065. The left MFL between both genders had a mean difference of 0.614 with a standard deviation of 0.642 and a standard error of the mean of 0.068. The right RFL between both genders had a mean difference of 0.589 with a standard deviation of 0.742 and a standard error of the mean of 0.078. The left RFL between both genders had a mean difference of 0.516 with a standard deviation of 0.607 and a standard error of the mean of 0.064.

Tables 4 and 5 show the various bivariate regression models for predicting stature (S) using bilateral hand parameters for both sexes. For the male category, the model developed for estimating stature using left and right HL was expressed as: S = 96.03 + 10.34(R-HL) – 6.61(L-HL). The model developed for estimating stature using left and right IFL was expressed as: S = 84.07 – 3.04(R-IFL) + 15.51(L-IFL). The model developed for estimating stature using left and right MFL was expressed as: S = 77.79 – 10.19(R-MFL) + 22.21(L-MFL). Finally, the model developed for estimating stature using left and right RFL was expressed as: S = 93.46 + 12.00(R-RFL) – 1.62(L-RFL). For the female category, the model developed for estimating stature using left and right HL was expressed as: S = 109.99 + 1.58(R-HL) + 1.18(L-HL). The model developed for estimating stature using left and right IFL was expressed as: S = 129.87 – 6.82(R-IFL) + 11.94(L-IFL). The model developed for estimating stature using left and right MFL was expressed as: S = 111.75 – 3.20(R-MFL) + 10.05(L-MFL). Finally, the model developed for estimating stature using left and right RFL was expressed as: S = 93.46 + 12.00(R-RFL) – 1.62(L-RFL).

Table 4. Summary of bivariate regression models for predicting stature (S) using bilateral hand parameters (Isoko males)

Parameters	R	R^2	Adj. R^2	SEE	p-value	F	Regression Equations
HL	0.668	0.446	0.434	6.327	<0.001	35.08	**S = 96.03 + 10.34(R-HL) – 6.61(L-HL)**
IFL	0.728	0.529	0.519	5.834	<0.001	48.94	**S = 84.07 – 3.04(R-IFL) + 15.51(L-IFL)**
MFL	0.777	0.604	0.595	5.351	<0.001	66.34	**S = 77.79 – 10.19(R-MFL) + 22.21(L-MFL)**
RFL	0.583	0.340	0.325	6.907	<0.001	22.44	**S = 93.46 + 12.00(R-RFL) – 1.62(L-RFL)**

HL = Hand length, IFL = Index Finger Length, MFL = Middle Finger Length, RFL = Ring Finger Length, R = Right, L = Left, Adj. = Adjusted, SEE = Standard Error of Estimate, p-value less than 0.05 is considered statistically significant

Table 5. Summary of bivariate regression models for predicting stature (S) using bilateral hand parameters (Isoko females)

Parameters	R	R^2	Adj. R^2	SEE	p-value	F	Regression Equations
HL	0.547	0.299	0.283	4.450	<0.001	18.54	**S = 109.99 + 1.58(R-HL) + 1.18(L-HL)**
IFL	0.463	0.215	0.196	4.710	<0.001	11.88	**S = 129.87 – 6.82(R-IFL) + 11.94(L-IFL)**
MFL	0.520	0.271	0.254	4.538	<0.001	16.163	**S = 111.75 – 3.20(R-MFL) + 10.05(L-MFL)**
RFL	0.407	0.166	0.147	4.85308	<0.001	8.658	**S = 124.83 + 2.00(R-RFL) + 3.43(L-RFL)**

HL = Hand length, IFL = Index Finger Length, MFL = Middle Finger Length, RFL = Ring Finger Length, R = Right, L = Left, Adj. = Adjusted, SEE = Standard Error of Estimate, p-value less than 0.05 is considered statistically significant

Discussion

In forensic, anthropological, and ergonomic research, hand and finger measurements have long been considered useful methods for estimating human stature (Adams & Herrmann 2009; Krishan *et al*. 2012). However, understanding the connection between these exterior body parts and stature is essential for developing accurate prediction models. A notable conundrum in the use of hand and finger lengths for stature estimation is the potential influence of hand dominance on these measurements, as it may lead to asymmetry between the right and left hands, resulting in variations in hand dimensions that could impact the accuracy of height predictions. In the current study, several hand and finger dimensions were examined to assess their relationship with stature in the adult Isoko population resident in Southern Delta University, Ozoro, Nigeria.

In this study, it was revealed that for every hand dimension examined, the right-hand measurements differed significantly from the left-hand measurements ($p < 0.05$) for both genders. The males exhibited larger mean differences than females across all parameters. In this present study, males displayed mean RHL and LHL differences of 1.009 cm and 0.877 cm greater than females, respectively. The corresponding mean differences between genders were 0.695 cm and 0.628 cm for right and left hands of the index finger, 0.715 cm and 0.614 cm for right and left hands of the middle finger, and 0.589 cm and 0.516 cm for right and left hands of the ring finger. Similarly, right-hand dominance has been seen in some Nigerian studies – albeit the reported differences vary depending on age, ethnicity, and geography (Oladipo *et al*. 2015; Okubike *et al*. 2018; Adefisan & Olopade 2024; Dhulqarnain *et al*. 2025). Moreover, several African forensic studies have highlighted the utility of hand measurements for sex estimation, noting that male hands are not only larger but also more laterally asymmetric (Habib & Kamal 2010; Ahmed 2013; Okwan *et al*. 2020; Banyeh *et al*. 2022; Hussein & Mohamed 2025).

Research on populations outside Africa has likewise identified significant differences between the two hands, although the direction of the asymmetry and its size differ across groups. For instance, research done among a Maldivian population by Mohamed *et al*. (2020) reported that males exhibited significantly larger hand and finger measurements compared to females, with male hand length averaging 19.49 cm (left) and 19.35 cm (right), while females averaged 17.33 cm (left) and 17.30 cm (right). In another related Bangladeshi study by Asadujjaman *et al*. (2019), the mean values for finger

lengths, such as index, middle, ring, and little fingers, were consistently higher in males than in females. The mean right-hand index finger length was 7.03 cm for males and 6.45 cm for females, and the middle finger lengths were 7.78 cm (males) and 7.15 cm (females). In another study by Zulkifly *et al*. (2018), this trend was supported by their results that showed highly significant differences ($p < 0.001$) for these hand and finger dimensions between sexes among the Malaysian population that was studied.

The perception of an individual and mental representation of their hands is influenced by hand dominance, possibly suggesting that the physical dimensions of their dominant versus non-dominant hands could differ systematically (Jones *et al*. 2021). Usually, dominant hands tend to be generally larger or more developed due to more frequent use, and hand asymmetries may develop over time because of differential usage patterns (Przybyla *et al*. 2012; Idenya *et al*. 2020). Therefore, it is only understandable that such asymmetries could impact the reliability of using hand or finger lengths for stature estimation, as measurements from the dominant hand might systematically differ from those of the non-dominant one. If hand dominance influences hand morphology, then measurements need to account for laterality to improve accuracy (Idenya *et al*. 2020). This present study is arguably the foremost study done using a Nigerian ethnic population to apply bilateral hand and finger lengths in deducing regression equations for predicting stature.

The regression equations deduced in the present study demonstrate significant relationships between stature and the studied hand parameters ($p < 0.001$). Among the Isoko males, the coefficients associated with right- and left-hand measurements within each equation suggest that both sides contribute to stature prediction. Moreso, the R^2 values for HL (0.446), IFL (0.529), MFL (0.604), and RFL (0.340). For the female category, the coefficients associated with right- and left-hand measurements for each equation suggested that they both contribute to stature prediction just like males. However, the R^2 values for the females were significantly lower, as HL had a value of 0.299, IFL (0.215), MFL (0.271), and RFL (0.166) in comparison to the R^2 values of males. This observation aligns with findings in previous literature, where studies have reported significant bilateral asymmetry in hand dimensions among various populations, often influenced by handedness and sex differences (Agnihotri *et al*. 2008; Asadujjaman *et al*. 2019; Mohamed *et al*. 2020). The greater R^2 values in males may be due to clearer sexual dimorphism in hand size and morphology, as well as more consistent bilateral

differences influenced by factors such as genetics and hormonal effects during puberty (Cabo *et al*. 2012).

Table **6**. A comparison of anthropometric measurements of related literature with present study.

Study Parameters (in centimeters)	**Sex**	Present Study **(Nigerian Isoko)**	Venkatesan *et al.* 2024 **(Indian)**	Yadav& Shakya 2020 **(Nepalese)**	Asadujjaman *et al.* 2019 **(Bangladeshi)**	Ibrahim *et al.* 2018 **(Saudi)**	Zulkifly *et al.* 2018 **(Malays)**
Mean Stature	Male	173.32	174.69	170.15	N. A	175.44	N. A
	Female	162.80	157.71	156.83	N. A	158.96	N. A
Mean Right Hand Length (RHL)	Male	20.21	N. A	N. A	18.48	20.11	18.51
	Female	19.20	N. A	N. A	16.71	18.65	17.30
Mean Left Hand Length (LHL)	Male	19.93	N. A	N. A	18.51	20.75	18.54
	Female	19.05	N. A	N. A	16.61	18.60	17.48
Mean Right Index Finger Length (R-IFL)	Male	7.38	7.27	7.16	7.03	7.54	6.91
	Female	6.68	6.65	6.60	6.45	6.88	6.52
Mean Left Index Finger Length (L-IFL)	Male	7.20	7.32	7.18	7.13	7.68	6.96
	Female	6.57	6.68	6.60	6.51	6.55	6.51
Mean Right Middle Finger Length (R-MFL)	Male	8.27	N. A	7.89	7.78	8.62	7.60
	Female	7.55	N. A	7.30	7.15	7.60	7.13
Mean Left Middle Finger Length (L-MFL)	Male	8.10	N. A	7.95	7.87	8.82	7.64
	Female	7.48	N. A	7.30	7.21	7.72	7.19
Mean Right Ring Finger Length (R-RFL)	Male	7.66	7.47	7.37	7.31	7.84	7.09
	Female	7.07	6.79	6.75	6.67	6.80	6.66
Mean Left Ring Finger Length (L-RFL)	Male	7.47	7.46	7.39	7.28	7.79	7.16
	Female	6.96	6.78	6.76	6.65	6.47	6.61

N. A = Not Available

Conclusion

The findings revealed significant differences in hand dimensions between right and left hands, with males exhibiting greater bilateral asymmetry. Also, the study results underscored the importance of developing tailored stature-prediction models for adult Isoko ethnic populations in the application of the bilaterality of these hand dimensions. While the present study provides a clear picture of bilateral hand asymmetry within a Nigerian Isoko sample, several limitations warrant consideration. Firstly, the most predominant hand dominance among participants was assumed to be right-handed, which could have influenced the study results because of their significantly higher right-hand anthropometric parameters. Lastly, the sample size, though adequate for detecting statistical significance, may limit the generalizability of effect-size estimates to broader Nigerian Isoko populations.

A key direction for future research may include expanding the sample size and geographic coverage of the sample population, as larger sample sizes reduce sampling error, improve power to detect small-to-moderate effect sizes, and enable subgroup analyses like age, sex, and region. Also, embarking on a cross-ethnic comparative study could expose whether the observed asymmetry is unique to Isoko people or reflects broader Nigerian patterns, which informs forensic comparisons. Finally, there may be a need to investigate functional and occupational correlates since hand asymmetry is linked to task-specific occupations such as farming, carpentry, etc.

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