Naif Arab University for Security Sciences
Arab Journal of Forensic Sciences & Forensic Medicine
المجلة العربية لعلوم الأدلة الجنائية والطب الشرعي
https://journals.nauss.edu.sa/index.php/AJFSFM

Potential and Accuracy of Hand Length and Hand Breadth in Sex Determination: An Insight into Hausa Population of Nigeria

إمكانية ودقة طول واتساع اليد في تحديد الجنس: دراسة بين سكان الهوسا في نيجيريا

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Received 02 Oct. 2019; Accepted 16 June. 2020; Available Online 07 Sep. 2020

Abstract

The identification of an individual in mass disasters and traffic accidents is a fundamental goal in forensic investigations. However, it is suggested that every population needs anthropological reference data. The objectives of this study were to determine the potential and accuracy of hand length and hand breadth in sex determination among the Hausa population of Nigeria.

Random sampling was employed to select 204 male and 194 female subjects aged 18-30 years. Hand length and hand breadth were measured using standard protocols. Two-sample t-test, binary logistic regression, receiver operating characteristics curve, and Youden's index were used for determining sex using hand dimensions. Posterior probability and likelihood ratio were used to determine the favor odds of each category of hand dimension in sex discrimination.

A significant sexual dimorphism was observed in hand length and hand breadth with higher mean values in males. The variance of sex explained by hand param-

Keywords: *Forensic Science, Hand Dimension, Sex Discrimination, Hausa Population, Nigeria.*

المستخلص

إن تحديد هوية الفرد في الكوارث الجماعية وحوادث المرور هو الهدف الأساسي في التحقيقات الجنائية. ومع ذلك، يقترح أن كل مجتمع يحتاج إلى بيانات أنثروبولوجية مرجعية. وتهدف الدراسة لتحديد إمكانات ودقة طول واتساع اليد في تحديد الجنس بين سكان الهوسا في نيجيريا. وقد تم استخدام عينة عشوائية لاختيار 204 من الذكور و194 من الإناث الذين تتراوح أعمارهم بين 18-30 سنة. وتم قياس طول واتساع اليد باستخدام البروتوكولات القياسية. كما تم استخدام اختبار t ثنائي العينة، الانحدار اللوجستي الثنائي، منحنى المميز لخصائص المستقبل، مؤشر Youden لتحديد الجنس باستخدام أبعاد اليد. وتم استخدام الاحتمال البعدي ونسبة الاحتمال لتحديد الفروقات لصالح كل فئة من أبعاد اليد في التمييز الجنسي. وقد لوحظ مثنوية شكل جنسية ذات دلالة إحصائية في طول واتساع اليد مع ارتفاع القيم المتوسطة في الذكور. وتراوح التباين في الجنس الموضح بمعلمات اليد بين 38.50% - 51.35% (الحدود الدنيا /

الكلمات المفتاحية: علوم الأدلة الجنائية، أبعاد اليد، تمييز الجنس، سكان الهوسا، نيجيريا.

Production and hosting by NAUSS

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doi: 10.26735/VMOY2714

eters ranges from 38.50/51.35% (lower/upper limits) to 52.98/70.66%, which were exhibited by right hand length and left hand breadth respectively. The overall prediction and percentage accuracy of sex discrimination ranges between 80.40 to 86.70 % that were exhibited by right hand length and handbreadth respectively. We observed that left hand breadth exhibited higher Younden's index with an area under curve (AUC) ranging from 91.60% to 96.05%. We found that hand length of > 189.99 mm was indicative of male origin and hand breadth of > 79.99 mm was indicative of male origin. All hand parameters categories with a likelihood ratio greater than one were indicative of male origin. Categories of hand dimensions with absolute (100%) potential in sex discrimination were also observed.

Hand dimensions were sexually dimorphic and exhibited potential in sex discrimination using different statistical inferences.

العليا) إلى 52.98% – 70.66%، والتي تم عرضها من خلال طول اليد اليمنى واتساع اليد اليسرى على التوالي. وتراوح التنبؤ العام والنسبة المئوية للتمييز بين الجنسين بين 80.40% و 86.70% والتي تم عرضها من خلال طول اليد اليمنى واتساع اليد على التوالي. ولوحظ أن اتساع اليد اليســرى أظهر أن ارتفاع مؤشر Younden مع منطقة تحت المنحنى (AUC) يتراوح بين 91.60% – 96.05%. ووجد أن طول اليدين> 189.99 مم كان يدل على أصل ذكوري واتساع اليد > 79.99 مم كان يدل على أصل ذكوري. وكانت جميع فئات معلمات اليد التي تزيد فيها نسبة الاحتمال عن واحد تدل على أصل ذكوري. كما لوحظت فئات من أبعاد اليد مع إمكانية مطلقة (100%) في التمييز على أساس الجنس.وكخلاصة فإن أبعاد اليد تتميز بمثنوية شكل جنسية وبيّنت إمكانات في التمييز الجنسي باستخدام استنتاجات إحصائية مختلفة.

1. Introduction

The human population demonstrates sexual dimorphism in different body parts, which are commonly employed in sex identification [1]. The human hand is the most versatile and adaptable part of the body which is of great scientific application in various fields such as anthropometry, forensic pathology, orthopedic surgery and ergonomics [2]. Hands are considered to be one of the sexually dimorphic parts of the body that exhibited potential as a useful tool in sex determination among different populations across the globe [3, 4, 5, 6, 7, 8]. Sexing is the leading parameter in the identification process in forensic anthropology [9, 10].

Following higher incidences of acts of terrorism, bombing, mass disasters (natural or artificial), and traffic accidents, it is not unusual to come across dismembered human remains including peripheral parts of the body such as hands. Identification of an individual involved in such incidences is a fundamental goal of forensic investigations. However, population differences in anthropological data have been noted and it is suggested that every population needs to document reference anthropological data. Moreover, it was affirmed that hand parameters are one of the variables that vary across different ethnic groups [11, 12]. Therefore, we conducted the present study to provide anthropological reference data of hand lengths and hand breadth among the Hausa population of Kano state, Nigeria, with the following objectives (i) to determine the sexual dimorphism in hand dimensions, (ii) to provide frequency distribution of different categories of hand dimensions, (iii) to provide regression models that can be used in sex discrimination using hand dimensions and (iv) to provide the cut-off values of hand dimensions that could discriminate between sexes.

2. Materials and Methods

2.1 Study location and design

The study was conducted at Bayero University Kano (a Federal university) and Maitama Sule University, Kano (a state University) in the Kano metropolis in Nigeria. The study design was a cross sectional type.

2.2 Sample size and selection criteria

The minimum sample size was determined using a standard formula [13]:

$$n = \frac{Z^2 Pq}{d^2}$$

Where; n= minimum sample size, Z= standard normal deviation with confidence interval of 95% (±1.96), P= proportion in the target population (50%) 0.5, q= 1-p, 1-0.5= 0.5, d = sampling error which is 5% (0.05)

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384$$

384 was therefore the minimum number of subjects needed for the study to allow a meaningful statistical

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analysis.

We randomly selected 398 (204 males and 194 females) participates (with 3.65% increment above minimum sample size) in the study based on the study selection criteria. The participants were within the age range of 18-30 years with a mean age of 21.67 ± 2.55 years. We excluded any participant with physical deformity in the hand that would interfere with measurement of hand length and hand breadth. Only those participants who belonged to Hausa ethnic group, up to the level of grand parentage, were included. Informed consent was sought from the participants before enrolment in the study. A simple data sheet was designed for recording of sex, age, and ethnicity of the participants. The study was conducted based on the ethical guidelines of Helsinki Declaration. The protocols involved in the study were approved by the Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Science, Bayero University Kano.

2.3 Determination of hand parameters

The technique for measuring the hand length and handbreadth were according to previous studies [7, 8], where the hand length was measured as straight distance from the mid-point distal crease of the wrist joint (line joining the most distal point on the styloid processes of radius and ulna) to the tip of the middle finger. Handbreadth was measured as a straight distance from the most laterally placed point on the head of 2nd metacarpal bone to the most medially placed point located on the head of 5th metacarpal bone where they form metacarpophalangeal joint. The repeatability and reliability of this method was reported elsewhere in the literature [8]

2.4 Calculation of likelihood ratio and favor odd

The calculated LR gives the strength of support the HP for one of the hypotheses: C or C'. Posterior probabilities P(C/HP) and P (C'/HP) were calculated using Baye's theorem [14]. Favored odds for support HP of the most likely hypothesis for a given hand parameter P (HP/C) and P (HP/C') were obtained from information of both the LR computations and posterior probabilities. The likelihood ratio (LR) was calculated using relative frequency of hand parameters (HP). The likelihood ratio (LR) was calculated as

$$LR = \frac{\text{probability of observing a given hand parameters if the donor was male (C)}}{\text{probability of observing a given hand parameters if the donor was female (C')}} = \frac{P\,(HP/C)}{P\,(\frac{HP}{C'})}$$

Where $HP = \frac{\text{Frequency of a given hand parameters}}{\text{Total frequency of all hand parameters}}$, C is the male donor, and C' is the female donor, and assuming the equal probability between the sexes P(C) = P (C') = 0.5.

The hand parameter with LR of > 1 is more likely to be of male origin. The favor odd (FO) was calculated as; FO =

$$\frac{P\,(HP/C)}{P\,(HP/C) + P\,(HP/C')}$$

Frequencies for different types of hand parameters were also determined.

2.5 Statistical analyses

The data were expressed using descriptive statistics (mean ± SD, minimum and maximum), frequency, and percentage. Two sample t-test was used for comparison of hand parameters between sexes. Binary logistic regression analysis was used to produce a model for sex prediction using hand parameters. Stepwise multiple (forward conditional) binary logistic regression analysis was also employed to determine the hand parameters that best predict the sex. The receiver operating characteristics (ROC) curve was used to evaluate the discrimination of the capability of hand parameters for sex determination. Youden's index was used to determine the optimum cut off value of hand dimensions with the best combination of specificity and sensitivity for sex discrimination. The analyses were conducted using SPSS version 20 (IBM Corporation, for Windows). $p < 0.05$ level was set as level of significance.

3. Results

Table-1 shows descriptive statistics and sexual dimorphism in hand length and hand breadth. A lower value was observed in all dimensions in females and higher value was noted in all dimensions in males. A significant sexual difference was observed in hand length and handbreadth with higher mean values in males compared to females. The hand breadth expressed more sexual dimorphism compared to the hand length. For both hand length and breadth, the left side was more sexually dimorphic than the right. The 95% confidence interval of the mean difference is narrowest in left handbreadth and widest in the right-hand length.

Figures-1 and 2 showed comparison of the contribution of sex to the total frequency of different categories of hand length and breadth. In both right and left hands, no male participant had a hand length <170mm and a minimal number of females had the hand length >199.99. Similarly, for hand breadth no male and female participants had measurement <70mm and >99.99 mm respectively. The vast majority of the study population had the hand measurements between 180-199.99 mm for hand length and 70-89.99 mm for handbreadth. Within the ranges, the female dominated180-189.99 mm for hand length and 70-79.99 mm for hand breadth, whereas the male dominated 190-199.99 mm for hand length and 80-89.99 mm for hand breadth.

Table-2 shows components and statistics of regression models for the prediction of sex from hand length and hand breadth. It was observed that all models of the hand parameters significantly predict sex. Both the coefficient of the hand parameters and the constants contributes significantly to sex discrimination. The variance of sex explained by hand parameters ranges from 38.50/51.35% (lower/upper limits) to 52.98/70.66%, which was exhibited by right-hand length and left-hand breadth, respectively. The stepwise (forward conditional) multiple binary logistic regression analyses that included left hand length and hand breadth explained the variance of sex by 56.97/75.97%. The best sex discriminator was the left-hand breadth. The overall prediction and percentage accuracy of sex discrimination of hand length and breadth ranges between 80.40 to 86.70 % which were exhibited by right hand length and breadth, respectively. The prediction accuracy reveals more misclassification among females compared to males hence, the percentage accuracy was more in favor of males than in females (Table-3).

Figure-3 shows the ROC curve for sex discrimination using hand length and handbreadth. All the hand parameters were above the reference line. The left-hand length was further from reference line than any of the hand pa-

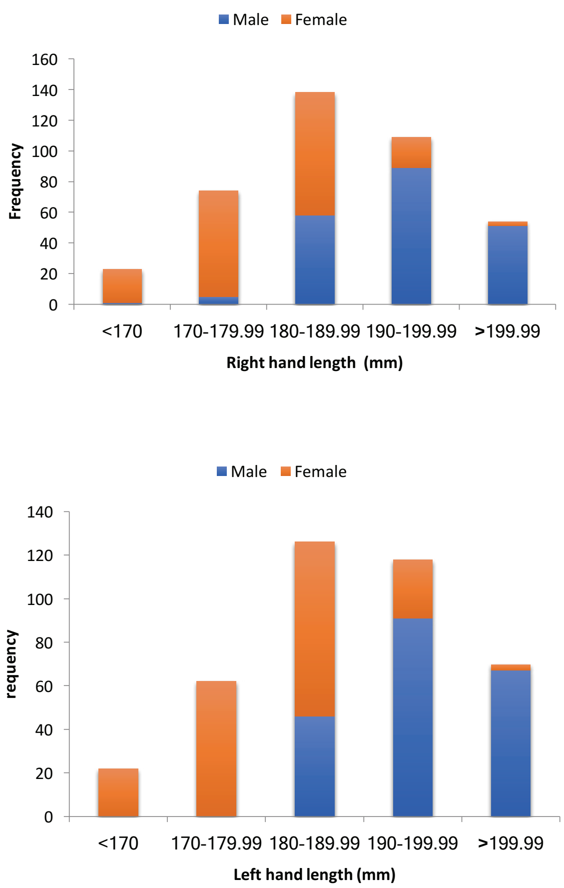

Figure 1- *Comparison of the contribution of sex to the total frequency of different category of hand length.*

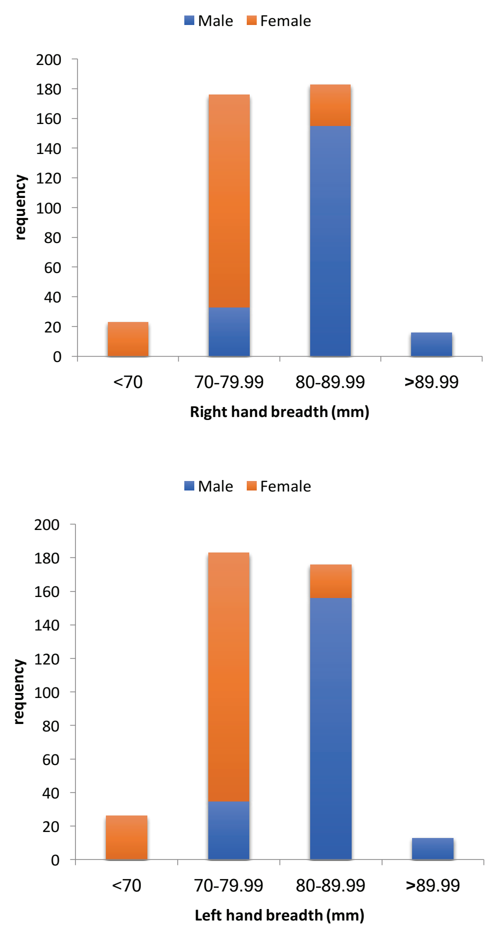

Figure 2- *Comparison of the contribution of sex to the total frequency of different category of hand breadth.*

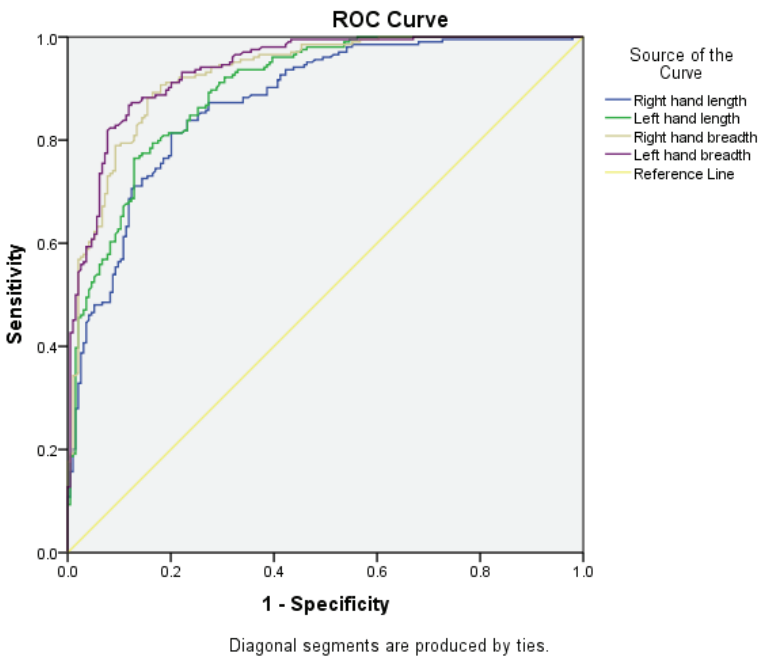

Figure 3- *Receiver operating characteristics curve for sex discrimination using hand length and hand breadth.*

Table 1- *Descriptive statistics and sexual dimorphism in hand length and breadth.*

Hand parameters (mm)	Sex	Minimum - Maximum	Mean ± SD	95% CI of MD Lower	95% CI of MD Upper	t-value	*p*- value
Right hand length	Male	158.70 - 216.79	194.21 ± 8.65	12.21	15.80	15.36	4.31×10^{-42}
	Female	136.92 - 205.25	180.21 ± 9.54				
Left hand length	Male	174.53 - 218.54	196.52 ± 8.26	13.84	17.39	17.28	2.83×10^{-50}
	Female	140.33 - 207.96	180.90 ± 9.73				
Right hand breadth	Male	70.34 - 113.40	83.98 ± 4.52	7.88	9.65	19.46	1.11×10^{-59}
	Female	61.81 - 87.66	75.22 ± 4.46				
Left hand breadth	Male	72.66 - 95.35	83.47 ± 3.93	8.20	9.91	20.90	6.65×10^{-66}
	Female	55.35 - 88.15	74.42 ± 4.69				

SD; standard deviation, CI; confidence interval, MD; mean difference

Table 2- *Components and statistics of regression models for prediction of sex from hand length and hand breadth.*

Hand parameters (mm)	β	*p*- value	Constant	P- value	Cox & Snell R^2	Nagel kerke R^2	Chi^2	*p*- value
Right hand length	-0.1889	2.09×10^{-22}	35.35	2.62×10^{-22}	0.3850	0.5135	193.49	5.5×10^{-44}
Left hand length	-0.2221	3.38×10^{-23}	41.92	4.03×10^{-23}	0.4450	0.5934	234.33	6.8×10^{-53}
Right hand breadth	-0.5050	1.84×10^{-24}	40.15	2.23×10^{-24}	0.5061	0.6749	280.72	5.2×10^{-63}
Left hand breadth*	-0.5449	6.40×10^{-24}	43.09	8.88×10^{-24}	0.5298	0.7066	300.35	2.8×10^{-67}
Left hand length, left hand breadth	-0.1418, -0.4340	1.75×10^{-07}, 1.72×10^{-14}	61.03	8.70×10^{-21}	0.5697	0.7597	335.61	1.3×10^{-73}

*Constructed model is sex = β × hand parameter(s) + constant, the cut-up value is 0.5 (that is predictive probability is for female group membership). Value ≤ 0.5 is indicative of male gender and value > 0.5 is indicative of female gender, * the best hand parameter that predict sex [based on step-wise (forward conditional) multiple binary logistic regression analyses].*

Table 3- *Prediction and percentage accuracy of sex discrimination of hand length and hand-breadth.*

		Prediction accuracy		
Hand parameters	**Sex**	**Male**	**Female**	**% Accuracy**
Right hand length	Male	165	39	80.9
	Female	39	155	79.9
	Overall % accuracy			80.4
Left hand length	Male	165	39	80.9
	Female	38	156	80.4
	Overall % accuracy			80.7
Right hand breadth	Male	180	24	88.2
	Female	31	163	84.0
	Overall % accuracy			86.2
Left hand breadth	Male	180	24	88.2
	Female	29	165	85.1
	Overall % accuracy			86.7
Left hand length, Left hand breadth	Male	178	26	87.3
	Female	26	168	86.6
	Overall % accuracy			86.9

Table 4- *The specificity and sensitivity of the optimum cut-off value of hand parameters that best discriminate the sexes.*

Hand parameters (mm)	Cut-off	%Sensitivity	%Specificity	YI	%AUC (95% CI)	SE	*p*-Value
Right hand length	187.04	81.37	79.90	1.61	87.31 (83.91-90.70)	0.017	6.49×10^{-38}
Left hand length	190.70	76.47	87.11	1.64	89.79 (86.83-92.75)	0.015	6.92×10^{-43}
Right hand breadth	79.58	88.24	84.54	1.73	92.73 (90.26-95.21)	0.013	3.40×10^{-49}
Left hand breadth	79.50	86.76	88.14	1.75	93.83 (91.60-96.05)	0.011	1.18×10^{-51}

Dimension < cut off value = female, Dimension ≥ cut off value= male, YI; Younden's index, AUC; area under curve, SE; standard error.

Table 5- *Frequency distribution, posterior probability, likelihood ratio and favor odds of hand parameters for sex discrimination.*

		Frequency		P (HP)		P [P(HP/C or C')]			Favor Odds		
Hand Parameters	Groups	Male	Female	Male	Female	Males	Females	LHR	Male	Female	Indication (%)
RHL (mm)	<170	1	22	0.01	0.19	0.01	0.38	0.04	0.04	0.96	Female (96)
	170-179.99	5	69	0.04	0.59	0.07	1.18	0.06	0.06	0.94	Female (94)
	180-189.99	58	80	0.42	0.68	0.85	1.37	0.62	0.38	0.62	Female (62)
	190-199.99	89	20	0.65	0.17	1.30	0.34	3.80	0.79	0.21	Male (79)
	>199.99	51	3	0.37	0.03	0.74	0.05	14.52	0.94	0.06	Male (94)
LHL (mm)	<170	0	22	0.00	0.19	0.00	0.38	-	0.00	1.00	Female (100)
	170-179.99	0	62	0.00	0.53	0.00	1.06	-	0.00	1.00	Female (100)
	180-189.99	46	80	0.34	0.68	0.67	1.37	0.49	0.33	0.67	Female (67)
	190-199.99	91	27	0.66	0.23	1.33	0.46	2.88	0.74	0.26	Male (74)
	>199.99	67	3	0.49	0.03	0.98	0.05	19.07	0.95	0.05	Male (100)
RHB (mm)	<70	0	23	0.00	0.20	0.00	0.39	-	0.00	1.00	Female (100)
	70-79.99	33	143	0.24	1.22	0.48	2.44	0.20	0.16	0.84	Female (84)
	80-89.99	155	28	1.13	0.24	2.26	0.48	4.73	0.83	0.17	Male (83)
	>89.99	16	0	0.12	0.00	0.23	0.00	-	1.00	0.00	Male (100)
LHB	<70	0	26	0.00	0.22	0.00	0.44	-	0.00	1.00	Female (100)
	70-79.99	35	148	0.26	1.26	0.51	2.53	0.20	0.17	0.83	Female (83)
	80-89.99	156	20	1.14	0.17	2.28	0.34	6.66	0.87	0.13	Male (87)
	>89.99	13	0	0.09	0.00	0.19	0.00	-	1.00	0.00	Male (100)

RHL; right hand length, LHL; left hand length, RHB; right hand breadth, LHB; left hand breadth, HP; hand parameters, P; probability distribution, C= male donor=0.5 C'= female donor =0.5; LHR; likelihood ratio rameters which indicates its larger area under the curve (AUC) and discriminating potential. In Table-4, the optimum cut off values of all the studies hand parameters that best discriminate the sexes were revealed. It was observed that left-hand breadth exhibited higher Younden's index which shows the best combination of sensitivity and specificity for sex discrimination. The AUC expressed by the left-hand breadth ranges from 91.60% to 96.05%. The right-hand length in the other hands, exhibited the lowest Younden's index with AUC ranging from 83.91-90.70%.

Table-5 shows frequency distribution, posterior probability, LR, and favor odds of hand parameters for sex discrimination. It was observed that a hand length of >189.99 mm was indicative of male origin and a hand breadth of >79.99 mm was indicative male origin. All the hand parameter with a likelihood ratio greater than one were indicative of male origin. Both right and left hands breadth demonstrated absolute (100%) potential in sex discrimination. Similarly, the left-hand length also demonstrated the absolute (100%) potential in sex prediction.

4. Discussion

The significantly higher mean values of hand parameters in males compared with the female participants of the present study agrees with previous studies where male hand dimensions were shown to be consistently higher than those of the females across different populations [6, 9, 12, 15, 16]. This finding was further reaffirmed by the observed sexual dimorphism in the mean values of hand dimensions as shown by sex wise frequency distribution of the different hand dimensions. The sexual dimorphism is attributed to the early maturity of girls compared to boys; consequently, the boys have more years of physical growth than the girls [12]. It was also reported that growth trends in the extremities are linear through late adolescence but completed earlier in the females [17]. It is well known fact that, males have higher androgen hormones than females, hence, it is assumed that sexual dimorphism is due, at least in part, to increased androgen levels. These androgens play a role in building of muscle mass and skeleton in young adults [18,19]. Androgens also up-regulate Transforming Growth Factor (TGF)-β and Insulin-like Growth Factors (IGFs), which stimulate bone formation and longitudinal bone growth, and down regulate Interleukin (IL)-6, which stimulates osteoclastogenesis, whereas higher estrogen, levels inhibit longitudinal bone growth in women [19, 20, 21, 22, 23]. This further explains the higher body proportion in body parts, including hands as typical male characteristics.

Population variations in anthropological data have been documented and it is well imperative for each population to be studied separately [6, 24]. This study compared hand parameters of a sample of Hausa population with those in previously reported studies. It was noted that the mean hand length and breadth obtained in the present study is higher than that of Mauritius [4] and "Rajput" (North India) populations [25] but lower than that of other Indian populations, in males not in females [26]. The sexually dimorphic nature of hand parameters observed in this study is very similar to that of the upper Egyptian population [12] and the Saudi population [8]. This may be explained by inherited ethnic differences that exist among different populations [12]. Environmental factors such as variations in climatic conditions and life style may contribute to the observed population difference in the hand parameters.

Using the stepwise multiple logistic regression analyses, the left-hand parameters were the best discriminators of sex in the present study. This is in line with previous studies where left-hand dimensions exhibited better accuracy in sex prediction [6, 25]. Considering the fact that 90% of the world's populations have a right hand preference [27, 28] and the most frequently used hand (dominant hand) may be well developed compared to the non-dominant hand. This may lead somewhat to a morphologically and functionally more robust hand which would eventually manifest in the hand dimensions. Therefore, the left hand will be less influenced by the environmental factors including life style and as such contain more preserved hand morphology typical to a specific gender. However, the validity of this observation may be limited by occupational distribution in males and females. Females who engage in more manual work like males may tend to have hand morphology more similar to males when compared with their female counterparts and vice versa. This may lead to narrowing of the accuracy of hand dimensions in sex prediction especially in the most common dominant hand, the right hand. In the case of the Hausa ethnic group of the present study, while males are known to be the breadwinners of the family women are predominantly full time housewives. This invariably implies that male subjects of the present study are likely to be engaged in mechanical activities such as farming which are capable of altering the inherent morphology and dimensions of the hands. This could offer a plausible explanation to the prominence of sexual dimorphism observed in the hand dimension of the participants in the present study.

Our observation that hand breadth is a better sex predictor compared to hand length agrees with previous studies [6, 25], where handbreadth showed better accuracy in sex determination compared to the hand lengths. It could be speculated that the masculine morphological features that characterize the male hand manifests more along breadth measurement when compared with hand length and this may explain the superior performance of handbreadth in terms of sex prediction when compared with hand length. In agreement with this notion, it was reported that in the upper limb, the circumferences especially that of the mid extremities were systematically more sexually dimorphic than the lengths [29]. This may simply be due to the contribution of more developed muscles in circumference measurement, in males compared to the length of the body segments. Involvement of the sides of two metacarpophalangeal joints in measurement of handbreadth may be an additional factor that results in more sexual dimorphism in hand breadth sexual dimorphism in hand breadth. It may be suggested that any measurements of dimensions that incorporated more musculature and joint complex (e.g. circumferences, breadth etc.) may express more sex differences than a measurement with less of these features (e.g. length, distances etc.) of the same body segments.

Previous studies used sectioning points [6, 12, 25, 28] to determine the values of hand dimensions that best discriminate sex, but it was suggested that the use of cut-off points derived from ROC analyses was more accurate and of higher sensitivity [8]. In addition, the present study showed that cut-off value from ROC analyses resulted into more accurate and discrimination potential of hand dimensions than the regression analyses. It was suggested that the ROC curve through its AUC could be used to evaluate the performance of the several variables in the determination of sex [30], which expresses the sex discrimination power of each variable [31]. An AUC of >0.9 is deemed to be outstanding, >0.8–0.9 excellent, 0.7–0.8 acceptable, and <0.7 poor [32]. Hence, the hand length and handbreadth of the present study were within excellent and outstanding sex discrimination potential, respectively. Further analysis using posterior probability and likelihood ratio also demonstrated the potential of each category of hand dimensions in sex discrimination. This analysis has the potential of revealing 100% probability of sex inference, as observed in the left hand and the side of breadth categories. In a nut shell, all three statistical procedures (regression, ROC curve, posterior probability and likelihood) demonstrated the potential of hand dimensions in sex discrimination with acceptable accuracy. We, however, suggested the use of posterior probability and likelihood followed by ROC curve cut-off values and regression models. This is based on excellent discrimination potential, simplicity, and possible practical application.

In forensic identification, DNA analysis provides the most reliable results, but it is not commonly available for forensic investigations in developing countries due to cost-effectiveness especially in large sample analyses, such as mass disasters. For this reason, various techniques in forensic anthropology continue to be essential tools in identification of human remains using statistical considerations [25]. The results of the present study can be successfully applied when analyzing dismembered hands especially within the narrow age group in order to avoid variability of dimensions that may be proportionate to the build of an individual. A isolated hand globe in the criminal scene may be used to determine the hand dimensions of the potential users and subsequently the sex of the user. Sex prediction from hand dimensions like other important sex predictors may reduce the workload of the forensic investigator by half at the crime scene or samples recovered from disaster site, thereby elucidating of the inevitability of the present study on the determination of sex from hand dimensions.

5. Conclusion

In conclusion, hand dimensions are sexually dimorphic with males having higher mean values than females. Hand dimensions exhibited potential in sex discrimination using different statistical inferences. The handbreadth is a better predictor of sex compared with the hand length. The left side was a better predictor than the right. The overall best predictor of sex was left handbreadth.

Financial support and sponsorship
No support/self-funded.

Conflicts of interest
There are no conflicts of interest

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