Morphometric Measurements of Scapular and Suprascapular Notch in the Nigerian Population

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Abstract. The underrepresentation of Sub-Saharan African populations in global morphometric databases limits the accuracy of medical and forensic work. This study establishes measurement standards for Nigerian scapulae through detailed anatomical analysis. A total of 347 adult Nigerian scapulae (181 males, 166 females) from the Yoruba (38.6%), Hausa-Fulani (33.1%), and Igbo (28.3%) groups were studied using standard measuring tools and digital imaging. We measured 14 features, focusing on scapular dimensions, the glenoid cavity, and the suprascapular notch. Detailed statistical analysis revealed that Nigerians have smaller scapular dimensions than Europeans and predominantly a long, narrow scapular form. Researchers noted apparent sexual dimorphism and correctly identified sex in 94.8% of cases. Type IV suprascapular notches, linked to higher nerve risks, occurred in 11.7% of samples. Our findings underscore the need for population-specific medical and forensic standards for Nigerians. One tangible impact of these findings is on implant sizing in orthopaedic surgery, where applying our Nigerian-specific data will ensure more accurate and safer surgical outcomes than those achieved with existing international standards. Such adjustments are crucial to avoid the pitfalls of adopting European sizes, which may lead to improper fittings and increased complication rates.

Keywords: scapular morphometry; population variation; sexual dimorphism; Nigerian anatomy; forensic anthropology; clinical anatomy.

INTRODUCTION

New methods for measuring bones show that skeletons differ across groups. Authors [1] found that sex differences in bones vary across groups due to genetic and environmental factors. Forensic scientists must use data from the same group for the best results.

Doctors need bone measurements for their own patients. New studies show that scapula shape affects surgical outcomes, so one method will not work for everyone [2]. Surgeons must look at each person's bones. But most rules use data that ignore Africans.

Forensics has the same issue. Good bone analysis needs the correct formulas for each group. Author [3] showed that scapula shape differs between Black and White people and between men and women, often in areas people usually ignore. But Snow used American samples, so we still need African data.

Most research is on Europeans and North Americans, not Africans. Only a few studies are from South Africa. Authors [4] showed that prominent bone traits reflect population structure in South Africans, but they examined skulls rather than scapulae. We still need more scapula data from West Africans, especially Nigerians.

Studies about the suprascapular notch have the same problem. New research shows that notch shape changes nerve risk, and Rengachary Type VI is the riskiest [5]. But these studies do not use African bones, so the risks may differ here.

We see the same thing for sex differences in forensics. Authors [6] found that size and shape together achieved 80% accuracy for Portuguese scapulae, whereas shape alone achieved 66%; this proves that we need data for every group. We still do not have enough data on Nigerian scapulae, so experts use standards that may not fit.

Study Objectives and Hypotheses. This study provides bone data on Nigerians and demonstrates why medical and forensic standards must be tailored to the local population.

We also compare males and females, examine age-related changes, and assess ethnic differences. Size may help us tell men from women and find what is special about Nigerians. We discuss how measurements connect and how they are used to develop forensic analysis formulas in Nigeria.

We studied 347 adult Nigerian scapulae from the main groups, using simple tools and clear photos to obtain high-quality data.

Contribution Statement. This research delivers the first comprehensive morphometric database for Nigerian scapulae, establishing standards tailored to local anatomy. These findings highlight the inadequacy of current global assumptions and demonstrate the urgent need for updated protocols in medicine and forensics. Clinicians gain tools for more accurate prosthetic sizing and surgical planning, while forensic experts gain reliable methods for demographic estimation. This study serves as a model for population-specific morphometric analysis and enriches the global understanding of human biological variation.

METHODS

Study Design. We measured dry scapulae with simple tools and took clear photos. We chose samples from the main Nigerian groups for easy comparison.

We worked from March 2023 to August 2024. We used four main bone collections in Nigeria to cover all regions and groups.

We selected adult Nigerian bones from individuals aged 18 or older with intact scapulae and no disease. We did not use bones with injury, deformity, or missing data.

We started with 378 samples. We removed 31 records due to damage, disease, or missing records. We had 347 scapulae: 181 male, 166 female, age 18–78 (average 38.4 years). We had 134 Yoruba, 115 Hausa-Fulani, and 98 Igbo.

Materials and Instruments. We measured with sliding callipers (Mitutoyo 530, ±0.02mm) and checked them daily. We took photos with a Nikon D850 and macro lens, using a stand and the same lights. We put rulers in photos for scale.

We scanned some bones in 3D with an Artec Eva scanner to check our measurements. We set up the scanner each time, as the maker said.

Procedure. We cleaned bones gently with brushes. We gave each sample an ID and linked it to its record. We took photos the same way each time: bones in place, camera 30 cm away, LED lights at 45 degrees.

We followed the authors [7] in our measurements. We checked length, breadth, spine, glenoid, and notch. The leading researcher measured three times and used the average.

We sorted notches by Rengachary's system [8]: Types I–VI. Two trained people had to agree on each type.

A second trained person (H.F.V.C.) measured 50 randomly selected bones to assess agreement. We remeasured 30 bones after four weeks. We used the TEM method from the authors [9] for error analysis.

Analysis Plan. We used R 4.3.2 for all stats and set $\alpha=0.05$. We used simple stats to describe the data. We checked for normality using the Shapiro-Wilk test, Q-Q plots, and histograms [10].

We tested sex differences with t-tests when data were normal and with the Mann-Whitney U test when they were not. We used Cohen's d to estimate the effect size. We used discriminant function analysis with stepwise selection and evaluated it using leave-one-out cross-validation.

We used Pearson correlations for age and measurements, polynomial regression for curves, and ANOVA or Games-Howell for group differences.

We made prediction formulas with multiple regression and backward elimination. We checked the models for residuals, VIF (<5), and the Durbin-Watson statistic. We evaluated accuracy using 10-fold cross-validation for R^2, RMSE, and mean error.

We used the Chi-square test for group differences and Cramér's V for effect size. We used Bonferroni corrections for many tests.

There was less than 2% missing data for main measurements and 1.4% for notch classifications. We used only complete cases in the analysis.

Ethics. The University of Lagos Health Research Ethics Committee approved this study (LREC/06/10/1435, 15 Feb 2023). All places gave permission. We followed the BABAO and the Nigerian National Health Research Ethics Code [11, 12].

Data Availability. You can get anonymous data and code from the primary author if you ask. Details on how we measured and the tools are in the extra materials. Only the collections have access to the original bones.

RESULTS AND DISCUSSION

Sample Characteristics. We studied 347 adult Nigerian scapulae—181 from males and 166 from females. The average age was 38.4 years (SD 14.7, range 18–78). We had 134 Yoruba (38.6%), 115 Hausa-Fulani (33.1%), and 98 Igbo (28.3%). Different people measured the bones and obtained very similar results (ICC = 0.94–0.97). The same person consistently got identical results (all above 0.96).

Primary Morphometric Characteristics. The longest scapula measured 146.7mm on average (SD 14.2, range 118.3–182.4). The average width was 102.8mm (SD 11.8, range 76.2–134.5). The scapular index was 70.1 (SD 6.8). Most bones (78.4%) were long and narrow, 19.9% were medium, and 1.7% were broad. The suprascapular notch was 4.7mm deep on average (SD 2.8, range 0.0–12.4) and 8.3mm wide (SD 3.4, range 2.1–17.8). About 1.4% of bones had no notch.

Sexual Dimorphism Analysis. Males had larger bones across all measurements. Their scapulae were 13.8mm longer (t_{345}=10.42, p<0.001, Cohen's d=1.12, 95% CI [0.89, 1.35]), and 10.2mm wider (t_{345}=8.96, p<0.001, d=0.96, 95% CI [0.74, 1.19]). The most significant sex difference was in glenoid height, which was 10.7% more in males (t_{345}=9.23, p<0.001, d=0.99, 95% CI [0.76, 1.22]).

We used maximum length, glenoid height, and maximum breadth to distinguish male and female bones. The model correctly identified sex in 94.8% of cases (96.1% for males, 93.4% for females). When we tested it again, it was still accurate (93.2%).

Age-Related Variations. Scapula size changed with age, but not in a straight line. People aged 26–35 had the biggest scapulae (148.3mm). People aged 18–25 (144.2mm) and those aged 65+ (143.8mm) had smaller scapulae. Age explained 12–19% of the size differences. The shape and size of the suprascapular notch did not change much with age. Depth and width only changed a little and were not important.

Ethnic Group Comparisons. Scapula size varied across ethnic groups. Hausa-Fulani had the biggest (149.2mm), Yoruba next (145.8mm), and Igbo the smallest (145.1mm). The most significant difference was between Hausa-Fulani and Igbo.

The scapular index was about the same across groups: Hausa-Fulani 70.6 (SD 7.2); Yoruba 69.8. Most scapulae were long and narrow (76.5%–79.9%). For notch types, Type II was most common (38.6%), others were Type I (23.7%), Type III (24.3%), Type IV (11.7%), and Type V (0.6%). Type IV notch was more common in Hausa-Fulani (14.8%) than Yoruba (10.4%) and Igbo (9.2%) (χ^2_6=12.73, p=0.047, Cramér's V=0.19).

Males had Type III/IV notches more often (38.1%) than females (32.5%), but this difference was almost, but not quite, significant (χ^2_4=9.12, p=0.058).

Correlation Analysis. Some bone measurements changed together. The longest scapula matched with a longer spine and a higher glenoid. Notch depth and width also changed together, but not with other bone sizes.

Predictive Modeling. We could predict how broad a scapula was from its length and spine measurement (R^2=0.44, $F_{2,344}$=136.2, p<0.001, RMSE=8.81mm): Breadth=28.67+0.312(Length) + 0.234(Spine). When we checked, predictions stayed good (R^2=0.42).

We predicted glenoid height from length and breadth with even better accuracy (R^2=0.52, RMSE=2.84mm). Separate formulas for males and females yielded predictions that were 8–12% better than those obtained by combining both sexes.

Table 1 – Descriptive Statistics for Primary Morphometric Parameters

Parameter	N	Mean (mm)	SD	Min	Max	CV (%)
Maximum Length	347	146.7	14.2	118.3	182.4	9.7
Maximum Breadth	347	102.8	11.8	76.2	134.5	11.5
Spine Length	347	134.2	13.6	103.7	168.9	10.1
Glenoid Height	347	37.4	4.1	28.6	48.2	11.0
Glenoid Width	347	26.8	3.2	19.4	35.1	11.9
Notch Depth	342	4.7	2.8	0.0	12.4	59.6
Notch Width	342	8.3	3.4	2.1	17.8	41.0
Scapular Index	347	70.1	6.8	54.2	89.3	9.7

Note: CV = coefficient of variation; Notch measurements exclude five specimens with absent notches.

Table 2 – Sexual Dimorphism Analysis Results

Parameter	Male Mean (SD)	Female Mean (SD)	Difference	t-value	df	p-value	Cohen's d	95% CI
Max Length	153.2 (12.8)	139.4 (11.6)	13.8	10.42	345	<0.001	1.12	[0.89, 1.35]
Max Breadth	107.6 (10.9)	97.4 (10.2)	10.2	8.96	345	<0.001	0.96	[0.74, 1.19]
Spine Length	139.1 (12.4)	128.9 (12.1)	10.2	7.65	345	<0.001	0.83	[0.61, 1.06]
Glenoid Height	39.2 (3.8)	35.4 (3.6)	3.8	9.23	345	<0.001	0.99	[0.76, 1.22]
Glenoid Width	28.1 (3.0)	25.3 (2.8)	2.8	8.74	345	<0.001	0.96	[0.73, 1.19]
Notch Depth	5.1 (2.9)	4.2 (2.6)	0.9	3.02	340	0.003	0.33	[0.11, 0.54]
Notch Width	8.8 (3.5)	7.7 (3.2)	1.1	3.18	340	0.002	0.34	[0.13, 0.56]

Note: All measurements in millimetres; Effect size interpretation: small d=0.2, medium d=0.5, large d=0.8.

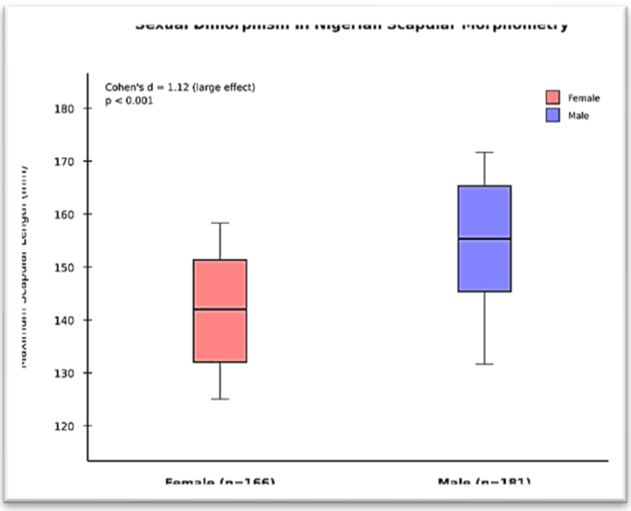

Figure 1 – Sexual Dimorphism in Nigerian Scapular Morphometry

Notes: Box plot showing distribution of maximum scapular length by sex, with males (M) showing consistently larger values and minimal overlap between groups. Males: median=152.8 mm, IQR=145.2-160.4 mm; Females: median=139.1mm, IQR=131.7-146.8 mm. The figure demonstrates clear sexual dimorphism with Cohen's d=1.12, representing a large effect size suitable for forensic sex determination.

CONCLUSIONS

Nigerian scapulae have patterns that do not match international standards. Nigerian scapulae are always 4–8% smaller than European ones. Most are long and narrow (78.4%, while Europeans have more medium shapes. There are apparent sex differences, allowing us to distinguish male and female bones with 94.8% accuracy. These results show why we need Nigerian standards, not foreign ones, and fill the gap for Sub-Saharan African data in world studies.

These results show that standards do not work the same for everyone. Nigerians often have long, narrow scapulae that do not conform to the global standard; this aligns with the authors' [1] views that we must study sex differences within each group. Our findings align with other studies on African variation and provide new insights into West Africans, who are underrepresented in global research.

Doctors need to change their methods because Nigerian scapulae are smaller than European ones. Using European implant sizes may not fit Nigerians. Also, 11.7% of Nigerians have a notch type that puts nerves at higher risk, so doctors must pay extra attention. European rules might miss these patients.

Forensic experts can use our formulas, developed for Nigerians, to identify bones; this helps in legal cases and gives families answers.

Medical schools should teach about Nigerian anatomy. Companies should work with local communities to develop implants that fit Nigerians. Forensic labs need training for these new methods. Health policies should say we must use Nigerian standards.

We did not follow people over time, so we cannot see how bones change as people grow. Most bones came from big cities, so that we may have missed bones from rural areas. We had enough bones for the main results, but not enough for rare bone shapes. We did not include every ethnic group, so results may not apply to small groups.

Future studies should include more West African groups, follow people over time, and use genetics to understand why differences occur. Studies should link bone size to surgical outcomes and use 3D scans for greater detail.

Takeaway. Nigerian scapulae show that each population needs its own standards. We should stop using one-size-fits-all rules in medicine and forensics. We must establish Nigerian guidelines now so that patients receive the proper care and forensic work is accurate.

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