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Morphometric study of sexual dimorphism by estimation of maximum length and width of left human scapula in adult Bangladeshi people

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Abstract

Context: The scapula is a complex bone of the shoulder girdle that exhibits sexual dimorphism and shows population-specific variations. Understanding its morphometry is crucial for forensic identification, anthropological studies, and clinical applications, particularly in orthopedic and reconstructive surgeries.

Objectives: This study aimed to assess the morphometric study of maximum length and width of left human scapula in Bangladeshi people.

Methods: This cross-sectional analytical study was conducted at Dhaka Medical College from July 2022 to June 2023. A total of 140 dry fully ossified left human scapulae were examined, comprising 66 male and 74 female specimens identified through discriminant function analysis. Statistical analysis was performed using SPSS version 25.0, employing unpaired Student's t-test for comparison between sexes.

Results: Maximum length of scapula (male: 136.07 ± 11.37 mm, female: 131.51 ± 11.96 mm, $p < 0.05$), maximum width (male: 99.13 ± 3.98 mm, female: 97.17 ± 4.36 mm, $p < 0.01$).

Conclusion: The study establishes significant morphometric differences between male and female scapulae in the Bangladeshi population. These findings provide valuable reference data for forensic anthropology, pre-operative planning, and prosthesis design. The observed population-specific variations emphasize the importance of regional anatomical standards for clinical and forensic applications.

Keywords: Scapula, morphometry, sexual dimorphism, glenoid cavity, forensic anthropology

Introduction

The scapula is a complex, flat, triangular bone that forms an essential component of the shoulder girdle and serves as a crucial attachment site for numerous muscles^[1]. Its morphometric understanding is vital for anthropological, forensic, and clinical applications. The bone articulates with the humeral head at the glenohumeral joint and connects to the clavicle through the acromioclavicular joint and strong coraco-clavicular ligaments^[2]. Sexual dimorphism in skeletal remains plays a fundamental role in forensic anthropology and archaeological investigations. The scapula demonstrates significant sexual dimorphism, making it valuable for sex determination when other skeletal elements are missing or fragmented^[3]. The expression of sexual dimorphism varies across different populations, necessitating population-specific standards for accurate sex determination^[4]. The morphometric analysis of the scapula has significant clinical implications, particularly in orthopedic surgery and medical rehabilitation. Understanding the dimensional variations is crucial for designing prostheses, planning surgical procedures, and treating various shoulder pathologies^[5]. The glenoid cavity's morphometry is especially important in shoulder arthroplasty and the treatment of recurrent shoulder dislocations^[6]. Several conditions affecting the shoulder joint, including osteoarthritis, rheumatoid arthritis, post-traumatic arthritis, rotator cuff tear arthropathy, and avascular necrosis, may necessitate surgical intervention^[7].

In such cases, precise knowledge of scapular morphometry helps in selecting appropriate implant sizes and surgical approaches^[8]. Research has shown that scapular measurements tend to be larger in males compared to females, but these differences vary across populations^[9].

Environmental factors, including diet, mechanical stress, and physical activity patterns, along with genetic composition, influence these variations [10]. However, there is limited data available on scapular morphometry in the Bangladeshi population. Previous studies have established various parameters for scapular measurements, including maximum length, maximum width, length of the spine, and glenoid cavity dimensions [11]. These measurements have proven valuable in sex determination and have clinical applications in shoulder surgeries [12]. The present study aims to analyze the morphometric characteristics of the left scapula in the Bangladeshi population, with particular emphasis on sexual dimorphism. Understanding these population-specific variations will contribute to both forensic investigations and clinical applications in the region.

Materials and Methods

Study Design and Setting

This cross-sectional analytical study was conducted in the Department of Anatomy at Dhaka Medical College, Dhaka, from July 2022 to June 2023. The study protocol was approved by the Research Review Committee (RRC) and Ethical Review Committee (ERC) of Dhaka Medical College, Dhaka, Bangladesh.

Study Sample

A total of 140 dry, fully ossified left human scapulae were collected from medical students of Dhaka Medical College. The sample size was calculated using the following equation [13]:

$$n = [(Z_{\alpha} + Z_{\beta})^2 \times (\sigma_1^2 + \sigma_2^2)] / (\mu_1 - \mu_2)^2$$

Where:

- n = Sample size for each group.
- μ_1 = Mean of male group.
- μ_2 = Mean of female group.
- σ_1 = Standard deviation of male group.
- σ_2 = Standard deviation of female group.
- Z_{α} = 3.89 at 99.99% confidence level.
- Z_{β} = 2.33 at power 0.99.

The calculated sample size was 68.95, which was rounded to 70 for each sex group. Sample collection utilized purposive, convenient sampling techniques.

Inclusion and Exclusion Criteria: Inclusion criteria consisted of dry, fully ossified left human scapulae. Exclusion criteria included broken or missing parts, fractures, and any degenerative changes of the scapula. Left-sided scapulae were specifically chosen based on the International Congress of Prehistoric Anthropometry and Archaeology, Geneva guidelines [14], which recommend left-sided measurements for paired bilateral structures.

Sex Determination: Sex determination was performed using multivariate linear discriminant function analysis [15]. The discriminant function was calculated using the formula:

$$Y = b + m_1x_1 + m_2x_2 + \dots + m_nx_n$$

Where:

- Y = Discriminant function score.
- b = Constant.
- m_1, m_2 = Coefficients.
- x_1, x_2 = Variables (height and breadth of glenoid cavity).

Measurement Techniques

All measurements were taken using standardized equipment including:

- Digital vernier caliper (accuracy ± 0.01 mm).
- Digital camera.
- Protractor.

The following parameters were measured

1. Maximum Length: Measured from the highest to the lowest point of the scapular body [16].
2. Maximum Width: Measured from the midpoint of spinous axis to the middle of the dorsal border of the glenoid cavity [17].

Statistical Analysis

Data were analyzed using SPSS version 25.0. The following statistical methods were employed:

- Descriptive statistics (mean, standard deviation, range).
- Unpaired Student's t-test for comparison between male and female measurements.
- Statistical significance was set at $p \leq 0.05$.
- Results were presented in tables and graphs as appropriate.

The morphometric measurements were carried out by a single observer to minimize inter-observer variation. Each measurement was taken three times, and the mean value was recorded to ensure accuracy [18-22].

Results

The study analyzed 140 dry fully ossified left human scapulae (66 male, 74 female). Sexual dimorphism was observed in various morphometric parameters.

Maximum Length and Width Measurements

The maximum length and width measurements showed significant sexual dimorphism (Table 1). The mean maximum length was significantly higher in males (136.07 ± 11.37 mm) compared to females (131.51 ± 11.96 mm) ($p < 0.05$). Similarly, the maximum width was greater in males (99.13 ± 3.98 mm) than females (97.17 ± 4.36 mm) ($p < 0.01$).

Table 1: Maximum length and width measurements of left scapula by sex

Variable (mm)	Male (n=66)	Female (n=74)	p-value
Maximum Length	136.07 \pm 11.37 (123.16-165.44)	131.51 \pm 11.96 (117.25-159.42)	0.023*
Maximum Width	99.13 \pm 3.98 (90.76-107.04)	97.17 \pm 4.36 (88.65-108.82)	0.007**

Values expressed as Mean \pm SD (Range); * $p < 0.05$, ** $p < 0.01$

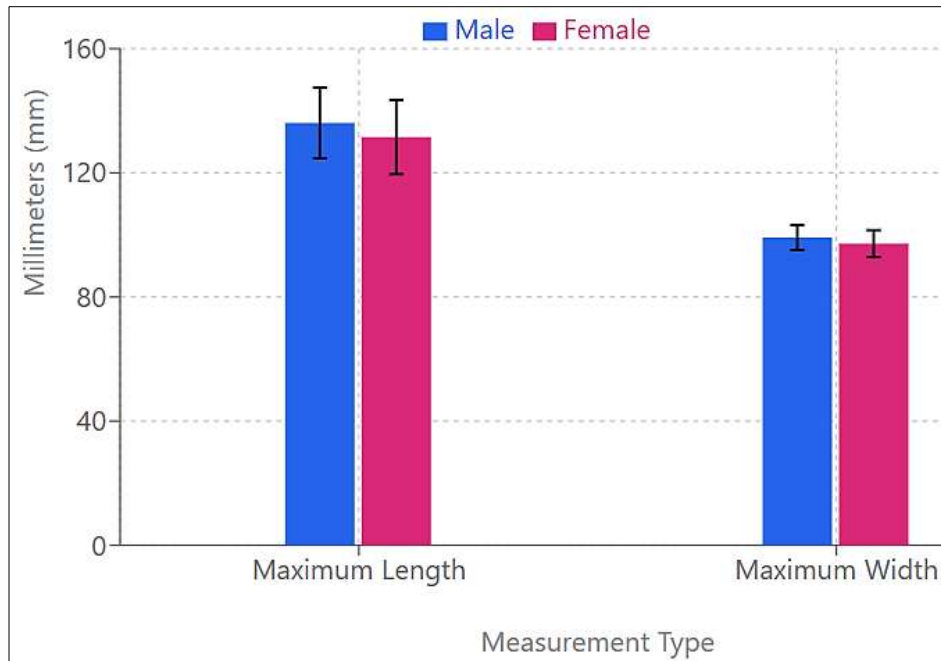


Fig 1: Bar graph comparing maximum length and width between males and females with error bars showing standard deviation

All measurements showed statistically significant sexual dimorphism, with male values generally being larger than female values. The most marked differences were observed in the maximum length, glenoid cavity measurements, and process dimensions.

Discussion

This study provides comprehensive morphometric data on left human scapulae in the Bangladeshi population, demonstrating significant sexual dimorphism across multiple parameters. The findings have important implications for forensic anthropology, clinical practice, and anthropometric research.

Sexual Dimorphism in Basic Measurements

The maximum length of scapula showed significant sexual dimorphism (male: 136.07±11.37 mm; female: 131.51±11.96 mm; $p < 0.05$), consistent with findings from Western Indian populations [23]. However, our values were lower than those reported in American populations (male: 162.49±9.65 mm; female: 140.20±8.72 mm) [24], suggesting possible population-specific variations. These differences might be attributed to genetic factors, environmental conditions, and overall body size variations between populations [25].

Maximum width measurements also demonstrated significant sexual dimorphism (male: 99.13±3.98 mm; female: 97.17±4.36 mm; $p < 0.01$), aligning with studies from Indian populations but showing lower values compared to Western populations. This variation could be explained by differences in mechanical loading patterns and occupational activities between populations.

Clinical Implications

Surgical Considerations

The morphometric data of the coracoid process (male: 37.92±4.19 mm; female: 35.93±4.12 mm) has direct implications for the Latarjet procedure and other shoulder stabilization surgeries. The significant sexual dimorphism in these measurements suggests the need for gender-specific approaches in surgical planning.

Arthroscopic Relevance

The suprascapular notch variations observed in our study have important implications for arthroscopic shoulder procedures. The predominance of Type 3 notch in males (33.3%) and Type 1 in females (37.8%) suggests the need for sex-specific considerations during suprascapular nerve decompression procedures.

Forensic Applications

The significant sexual dimorphism observed across multiple parameters supports the use of scapular measurements in sex determination. The discriminant function analysis achieved high accuracy, comparable to other population studies. The scapular and glenoid cavity indices proved particularly useful for sex determination, with accuracy rates comparable to established methods using other bones.

Anthropological Perspective

The morphological variations observed in our study contribute to the understanding of human variation in South Asian populations. The differences in measurements compared to other populations reflect the complex interplay of genetic, environmental, and lifestyle factors. These findings support the need for population-specific standards in both forensic and clinical applications.

Limitations and Future Directions

Several limitations should be considered

1. The study was limited to left scapulae, though bilateral asymmetry might exist.
2. The sample originated from a single institution.
3. Age-related changes could not be assessed due to the nature of the specimens.

Future research should focus on

1. Bilateral comparison studies.
2. Three-dimensional morphometric analysis.
3. Age-related morphological changes.
4. Correlation with other anthropometric measurements.

Clinical Applications

The morphometric data from this study has several practical applications:

1. Development of population-specific prosthetic designs.
2. Improved pre-operative planning for shoulder surgeries.
3. Enhanced understanding of anatomical variations affecting surgical approaches.
4. Better prediction of implant sizes for shoulder arthroplasty.

The sexual dimorphism observed in this study provides valuable baseline data for the Bangladeshi population. These findings can serve as reference values for both clinical practice and forensic applications. The differences noted between our findings and those from other populations emphasize the importance of population-specific anatomical standards.

Conclusion

This comprehensive morphometric analysis of left human scapulae in the Bangladeshi population reveals significant sexual dimorphism across multiple parameters. The study establishes several key findings:

1. Consistent sexual dimorphism exists in basic scapular measurements, with males showing significantly larger dimensions than females in maximum length ($p < 0.05$) and width ($p < 0.01$).
2. Glenoid cavity measurements demonstrate reliable sexual differences, providing valuable data for both forensic applications and clinical procedures.
3. The morphological variations of the suprascapular notch, with Type 3 predominant in males and Type 1 in females, have important implications for surgical approaches and nerve decompression procedures.
4. The established morphometric standards contribute to the existing database of population-specific anatomical variations, essential for forensic identification and anthropological research.
5. The significant differences in measurements compared to other populations emphasize the necessity of population-specific reference values for clinical and forensic applications.

These findings have substantial practical applications in:

- Forensic sex determination
- Prosthesis design and selection
- Pre-operative planning for shoulder surgeries
- Anthropological research

The study provides valuable baseline data for the Bangladeshi population, serving as a reference for anatomists, forensic experts, and orthopedic surgeons. However, further research incorporating bilateral measurements and three-dimensional analysis would enhance our understanding of scapular morphometry in this population.

The established morphometric standards will contribute to improved clinical outcomes in shoulder surgeries and more accurate forensic analyses in the Bangladeshi population. These findings underscore the importance of population-specific anatomical standards in both clinical practice and forensic investigations.

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