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MORPHOMETRIC STUDY AND ITS APPLICATION IN SEXUAL DIMORPHISM OF SCAPULA

Dr Vanju V.V Lakshmi[1], Dr M Sushma[2,] Dr Vannala Bangarayya[3], Dr P Lakshmana rao[4*]

[1]Assistant Professor, Department of Anatomy, Government Medical College, Srikakulam.

[2]Assistant Professor, Department of Anatomy, Government Medical College, Vizianagaram.

[3]Assistant Professor, Department of Anatomy. Andhra Medical College, Visakhapatnam.

[4*]Assistant Professor, Department of Anatomy, Government Medical College, Vizianagaram.

Corresponding Author: Dr P Lakshmana rao

Assistant Professor, Department of Anatomy, Government Medical College, Vizianagaram.

Abstract:

Background: Estimating biological diversity, or ancestry, has been one of the corner stone of forensic anthropological investigation since 19th century. Biological profile includes four components age, sex, ancestry and stature. Out of which sex is most important for ability to positively identify human skeletal remains.

Aim and Objectives: The aim of the study is to examine the sexual dimorphism in the morphometry of the scapula.

Materials and Methods: A cross-sectional study was conducted using 200 randomly collected adult cadaveric dry scapulae of known sex of both sides (148 females, 52 males) , from October 2019 to October 2022 in the department of Anatomy, GIMSR, Visakhapatnam. The metric analysis of scapula were done and compared in both sexes.

Results: Mean, range and standard deviation were calculated for individual parameters. These Parameters were subjected to multivariate discriminate analysis, out of which three were found to be most sexually dimorphic.1. Maximum width of glenoid fossa [MWG]-96% 2.Maximum distance between acromion and coracoid process [MDAC]- 92.5%,3. Length of Supraspinous line [LSSL]- 86%.

Conclusion: This study has confirmed that sex can be determined with high accuracy using scapular measurements and accuracy can be improved by deriving logistic regression score.

Keywords: Maximum width of glenoid fossa , Maximum distance between acromion and coracoid process, Length of Supraspinous line.

INTRODUCTION

The name scapula as synonym of shoulder blade is of Latin origin.(4)Scapula resembles a trowel that means a small shovel. The scapula (shoulder blade) is a triangular flat bone that lies on postero lateral aspect of thorax, overlying the 2nd to 7th ribs. It has costal and dorsal surface, superior, lateral, medial borders, inferior, superior, lateral angles, three process, the spine, its continuation the acromion and the coracoid process three angles superior, inferior, lateral, and three fossa supraspinatus, infraspinatus, subscapular. The lateral angle is truncated and bears glenoid cavity for articulation with the head of humerus. (5)

MATERIAL AND METHODS

This study was conducted using 200 randomly collected adult cadaveric dry scapulae of known sex of both sides (148 females, 52 males) of mixed Indian population in the department of anatomy, Gitam Institute of medical sciences. The study design was cross sectional and observational, studied with in the period from february 2019 to february 2022.

In this study we have mainly focused on metric analysis. In metric method twelve measurements were taken by using digital vernier caliper (accurate to 0.1mm) and readings were recorded in mm. During the course of study we have noted prominent morphological difference between male and female scapula was noted.

Fig-1: This shows the bone studied in this project. The bones exhibited are scapula of both sexes

Table-1 Description of measurements

S.no	Measurement name	Measurement Description
1	Maximum height of scapula(MHS)	Distance from the superior most point on superior angle to the inferior most point on inferior angle
2	Maximum width of scapula(MWS)	Distance between middle of dorsal border of the glenoid fossa to the spinous axis at the vertebral border
3	Length of scapular spine (LSS)	From the spinous axis to the most lateral extent of the acromion process.
4	Maximum distance between acromion and coracoid processes(MDAC)	Between anterior point of coracoid process to the posterior point of the acromion
5	Maximum length of acromion process	distance between the most superior and inferior point on

	(MLA)	the acromion
6	Maximum length of coracoid process(MLC)	Measured form the base to the tip of the coracoid process
7	Maximum length of glenoid fossa (MLG)	From the superior margin to the inferior margin of the glenoid prominence
8	Maximum width of glenoid fossa (MWG)	Maximum breadth of the articular margin, perpendicular to the glenoid cavity height
9	Length of axial border (LAB)	From the most inferior point of glenoid fossa to the inferior most point of the inferior angle
10	Maximum depth of suprascapular notch (MDSSN)	Imaginary line from superior corners of notch to the deepest point of the supra scapular notch.
11	Length of infra spinous line (LISL)	Distance between inferior most point of inferior angle to the spinous axis of vertebral border
12	Length of Supraspinous line (LSSL)	Distance between most superior point of superior angle and the spinal axis of vertebral border

RESULTS

In the current study the mean values of the maximum length of the scapula in male is 155.76mm and female is 149.89mm; mean values of the maximum width of scapula in male is 104.12mm and 99.4mm in female; mean values of maximum length and width of glenoid fossa in male is 35.54mm and 23.15mm and female is 31.52mm and 19.04mm respectively. The mean values of maximum lengths of acromion and coracoid is 23.15mm and 36.20mm in male and 19.04mm and 31.74mm respectively. The mean lengths of supraspinous and infraspinous line in male and female is 43.83mm, 105.91 mm and 35.05mm, 94.91mm respectively.

DISCUSSION

Many bones of human skeleton have been used to estimate the sex of unknown remains. These types of methodologies need to be tested and retested for accuracy and reliability, especially those methods that are shown to be population specific. Applying formulae developed for sex estimation in one population to a different population has been demonstrated to have less discriminatory power than when applied to the original population. For this reason, several other authors have produced metric sex estimation formulae for specific population using scapula to account for the observed variation in sexual dimorphism across regions. In India study data is very scarce on sexual dimorphism of scapula by using multivariate analysis. In order to fill this void, we applied multivariate analysis on measurements taken from scapulae belonging to a skeletal collection of mixed Indian population.

Metric method:

Means, maximum, minimum values, and standard deviation between sexes and those of left and right side recorded.

Comparisons of values of these parameters with those reported in other population and their clinical correlation are discussed in the fallowing sections fallowed by discussion on multivariate discriminate function analysis.

<u>**Discussion on individual variables:**</u>

1. Maximum height of scapula

In our study population it was found to be greater in males than in females which are in accordance with all other populations studied so far. When compared with the data available in Indian population by shailesh et al, our study population have over all higher values of maximum length of scapula in both sexes.

2. Maximum width of scapula

In our population maximum width of scapula was found to be greater in males than in females which are in accordance with all other populations studied so far. When compared with the data available in Indian population by shailesh et al, our study population have over all higher values of maximum width of scapula in both sexes.

3. Maximum length of glenoid fossa:

In our study population maximum length of glenoid fossa was found to be greater in males than in females which are in accordance with all other populations studied so far. Present study is comparable with study by Shailesh M patel in Gujarat, India. measurements are more are less similar to our study population

4. Maximum width of glenoid fossa

In our population maximum width of glenoid fossa was found to be greater in males than in females which are in accordance with all other populations studied so far. When compared with the data available in Indian population by shialesh et al, our study population have overall smaller width of glenoid fossa in both sexes.

5. Maximum length of acromion process:

In our population maximum length of acromion process was found to be greater in males than in females which are in accordance with the data of all other populations studied so far. However the mean of maximum length of acromion process was found to be higher in males and smaller in females than the data available for other non Indian population studied by various authors.

6. Maximum length of coracoids:

In our population maximum length of coracoid process was found to be greater in males than in females which are in accordance with the data of all other populations studied so far. However the mean of maximum length of coracoid process of both sexes was found to be smaller than the data available for other non Indian population studied by various authors.

7. Maximum length of scapular spine:

In our population maximum length of scapular was found to be almost equal in both sexes, studies in comparison showing that the length of scapular spine was found to be greater in males than in females. However the mean of maximum length of scapular spine both sexes were found to be smaller than the data available for other non Indian population studied by various authors.

8.Length of infraspinous line:

In our population maximum length of infra spinous line was found to be greater in males than in females which are in accordance with the data of all other populations studied so far.

9. length of supraspinus line:

In our population maximum length of supra spinous line was found to be greater in males than in females which are in accordance with the data of all other populations studied so far. However the mean of maximum length of infra spinous line of both sexes was found to be smaller than the data available for American population by Dabbas & Moore et al.

10. Maximum depth of suprascapular notch:

In our population maximum depth of supra scapular notch was almost equal in both sexes, studies in comparison showing that the maximum depth of suprascapular notch was found to be greater in males than in females.

11. Maximum distance between acromion and coracoid process:

In our population maximumdistance between acromion and coracoid process was found to be greater in males than in females which are in accordance with the data of all other populations studied so far. However the mean of maximum length of infra spinous line of both sexes was found to be smaller than the data available south Italian population by Dabbas & Moore et al.

MULTIVARIATE DISCRIMINATE FUNCTION ANALYSIS

Presented table showing results after performing stepwise statistics ,at each step, the variables that minimize over all wiks lambda is entered, maximum number of steps were performed are 24, minimum partial F to enter is 3.84, maximum partial F to remove is 2.71.

After using various parameters of scapula and their permutation and combination by using SPSS-20 soft ware we found fallowing three parameters are most sexually dimorphic.

Cross validation is done for only for these three variables, 96.0% of original grouped cases correctly classified and 96.0% of cross-validated grouped cases correctly classified.

Table: 1 All variables (MGW, MDAC and SSLC)

Variables	Total n	Males Correct n	Percentage	Total n	Females Correct n	Percentage	Total n	Total Correct	Total Percentage
Original Data	148	148	100.00%	52	44	84.6%	200	188	96.00%
Cross-validated	148	148	100.00%	52	44	84.6%	200	188	96.00%

Table: 2 Unstandardized coefficients and constant were reported for these variables

	Function
	1
mgw	.424
mdac	.033
ssl	.074

(Constant)	-14.306

Sectioning point/cut off point for sex assignment is reported as the mean between group centroids of males and females.

Table: 3 Functions at Group Cancroids

Gender	Function
	1
Female	-2.008
Male	.706

Sectioning point /Cut-off point= (-2.008+0.706)/2=-0.651

If the regression equation score (Y) is greater than the given sectioning point/ cut off point indicate that the individual is male, if less than cut off point individual is female.

Regression equation for determination of sex is as fallows

$$Y = m_1x_1 + m_2x_2 + m_3x_3 + _3..... + b$$

Regression Equation
Sex=0.424mgw+0.033mdac+0.074ssl-14.306
Mgw- maximum width of glenoid
Mdac- maximum distance between acromion and coracoid
Ssl- length of supra spinous line

Table:4

author	population	No of variables used	Regression equation
A.M.C.Murphy et al 1987	New Zealand	2	Sex= (0.095XGLENH)+ (0.476XGLENB)-17.80
Ismail ozer et al	medieval	4	y= (MSH x 0.024) + (MSB x 0.043) + (GCH x 0.316) + (GCB x 0.145) + (–22.838)
Dabbas& moore janson,2008	wichita	2-variable model	Sex=(0.212x XBS)+(0.201x XHS)-51.425
		3-variable model	Sex= (0.136x XLS)+(0.117xXHS)+(0.514x HAX)+(0.296XCSV)+(0.904XTLB)-66.186
G Dabbas et al 2010	Egyptian	5	Sex =(0.024x XLS)+(0.186xBXB)+(0.064X XHS) +(0.062X HAX)-54.335
Shailesh et al 2015	India, Gujarat	4	Sex= (-0.246XMSH)+(0.122XMSB)+- (0.486XGCH)+(-0.034+GCB)+35.356
Present study	India	3	Sex=(0.424XMGW)+(0.033XMDAC)+(0.074XSSLC)-

			14.306

Table: 5

AUTHOR	ACCURACY
Dewight	96.81%
Hani hara	94.2%-96.8%
Devilla	95%
Dabbas& moore janson	95.7%
Ozer	82.9%-95%
Murphy	85.7%-93.6%
G Dabbas	84%-88%
Present study	96%

Dwight suggested that both maximum length of the scapula and glenoid fossa height can be utilized in sex estimation, although he did not provide statistical analyses to support his assertions.

CONCLUSION

Twelve parameters were studied on 200 dried human cadaveric scapula of known sex of both sides of mixed Indian population. Metric analysis of these parameters was done. Mean, range and standard deviation were calculated for individual parameters. These Parameters were subjected to multivariate discriminate analysis, out of which three were found to be most sexually dimorphic. Level of accuracy in estimating sex in the decreasing order is as follows:

1. Maximum width of glenoid fossa [MWG]-96%
2. Maximum distance between acromion and coracoid process [MDAC]- 92.5%
3. Length of Supraspinous line [LSSL]- 86%

The combination of these three measurements also gave an accuracy rating of 96.0%.

Unknown scapulae of this region can now be sexed with the help of constant, unstanderdized coefficients, and sectioning points made available through this study. The sectioning point for the assignment of sex was designated as the midpoint between mean group centroids of the male and female. In the present study it was 0.651

The logistical regression equation was derived with the help of SPSS software.

Logistic regression score [y] is calculated as follows:

$$Y = (0.424 \times MGW) + (0.033 \times MDAC) + (0.074 \times LSSL) + (-14.306)$$

The sectioning point for the assignment of sex was designated as the midpoint between mean group centroids of the male and female. In the present study it was 0.651.

This equation gives the value of y, which is compared with the value of the sectioning point. Because the mean values of these parameters are greater in males than in females, *Y* greater than the sectioning point will indicate a male scapula, less than sectioning point indicates female.

There are various techniques available for sex determination of human skeletal remains, which can be utilized only on well preserved bones from relatively complete skeletons. In absence of intact or fragmented long limb bones, scapula can be reliably employed for the estimation of sex because, the anatomical land marks of these standard measurements are well defined and easy to locate. The utility of statistical formulae in forensic practice is becoming popular in recognizing the circumstances where no other portion of skeletal remains is present or adequately preserved.

Over the last hundred years, many researchers have developed methods for estimating sex which were population specific. It has been observed that these population specific measures are necessary because the accuracy of any method decreases if it is applied to a population other than the one for which it was developed.

In the present study, population specific logistic regression formula is derived which is helpful for sex determination of mixed Indian population. This study has confirmed that sex can be determined with high accuracy using scapular measurements and accuracy can be improved by deriving logistic regression score. However these findings can be confirmed as applicable to Indian population only after using a much larger and representative sample base.

Application of present work:

1. Findings of present study provide important morphometric data for population specific sexing of human remains of mixed Indian population. Results would be useful for sex determination in forensic, and medico legal cases where skull and pelvic bones are unavailable or damaged.

2. Dimensions of scapula and acromion process are important as they differ in morphology and when classified into different types, show linkage to the shoulder girdle pathologies. Data obtained from this study would be helpful for surgeons while working on shoulder joint.

3. Size of the glenoid cavity is known to be variable in different populations. Hence while designing the glenoid component of the prosthesis dimensions of the glenoid cavities in Indian population should be considered.

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