Original Research Article

# Determination of sex from morphometric analysis of scapula

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## Abstract

**Background:** Sex determination is important in medicolegal cases from the available parts of skeleton. **Aim and Objectives:** To test the usefulness of various measurements of scapulae for sex determination in western Indian population. To derive population specific logistic regression formula for determination of sex in western Indian population. **Materials and Methods:** 60 adult skeletons (35 males and 25 females) were used in the study. Various parameters of scapulae were measured in millimeter with the help of Vernier calliper. **Results:** Difference between various parameters in relation with sex is measured and found to be extremely statistically significant. **Conclusion:** The results of this study are useful for sex determination in medicolegal cases where the skull and pelvic bones are not available.

**Key Word:** Sex determination, Skeleton, Scapulae, Regression, Medicolegal.

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## INTRODUCTION

Sex determination is one of the most important aspects in medicolegal cases when skeletal remains were provided for the same. Accuracy of sex determination increases with availability of complete skeleton. To some extent individual bones can be used for sex determination. Various studies are available on Skull, pelvis, long bones, clavicle, patella, sacrum, sternum for determination of sex.[1-7] It is well established that Skull and pelvis are used to determine sex in medicolegal cases with greater accuracy. However, when these bones are damaged the accuracy of these bones decreases. The other bones mentioned above are often used in combination during forensic examinations for same purpose but again with lesser accuracy. Determination of sex using scapular measurements is very useful in medicolegal cases, natural disasters and in other circumstances in which other of skeleton are absent or fragmented. Accuracy increases with more number of measurements incorporated in single logistic regression formula.

## MATERIAL AND METHODS

For This study 60 adult skeletons (35 males and 25 females) with closed epiphysis and without damage were selected. These Scapulae of known sexes were taken from Dept. of Anatomy, Govt. Medical College, Miraj, Maharashtra, India.

Following Measurements of scapula were taken with the help of sliding caliper. All measurements were recorded in millimeter.

1. **Maximum scapular breadth (MSB):** Maximum distance between the point on the prolongation of the inferior boundary of the dorsal margin of the spine and the point on the longitudinal axis of the glenoid cavity.
2. **Maximum scapular height (MSH):** Maximum distance between the highest point of the superior angle and the lowest point of the inferior angle.

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3. **Glenoid cavity breadth (GCB):** Maximum breadth of the articular margin, perpendicular to the glenoid cavity height.
4. **Glenoid cavity height (GCH):** Maximum distance from the most prominent point of the supraglenoid tubercleto the inferior point of the glenoid margin.
5. **Calculated Area of Glenoid cavity (CAG):** It is the product of breadth and height of glenoid cavity. It is not the actual area of glenoid cavity so called as calculated area of glenoid area of glenoid cavity.

Data was statistically analyzed and results were tabulated (table no. 1). Descriptive statistics were calculated, and a student t-test for equal variances was applied to assess the difference between the means of the male versus female groups. Logistic regression equation was derived from stepwise method. All statistical calculations were done in Microsoft Excel software.

## RESULTS

Table 1 shows mean of the MSH, MSB, GCH, GCB and CAG with their standard deviation, standard error mean, *t*-value and *P* value for both males and females. There was statistically significant difference ($P < 0.0001$) between male and female for the mean value of all measurements. So it indicates the existence of strong sexual dimorphism in scapula in relation with these values.

**Table 1:** Showing Descriptive statistics

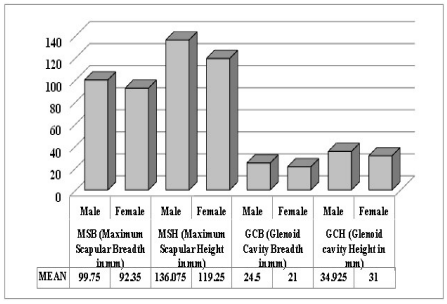
| Measurements of scapulae | No. of Scapulae | SEX | MEAN | Standard Deviation | Standard Error of MEAN | 't' Value | 'p' Value |
|---|---|---|---|---|---|---|---|
| MSB | 40 | Male | 99.75 | 1.891276 | 0.299 | 14.55 | 0.0001 |
| (Maximum Scapular Breadth) | 20 | Female | 92.35 | 1.785 | 0.399 | | ESS |
| MSH | 40 | Male | 136.075 | 1.542 | 0.244 | 40.05 | 0.0001 |
| (Maximum Scapular Height) | 20 | Female | 119.25 | 1.517442 | 0.33931 | | ESS |
| GCB | 40 | Male | 24.5 | 2.172084 | 0.343437 | 6.815 | 0.0001 |
| (Glenoid Cavity Breadth) | 20 | Female | 21 | 1.025978 | 0.229416 | | ESS |
| GCH | 40 | Male | 34.925 | 2.01771 | 0.319028 | 7.781 | 0.0001 |
| (Glenoid cavity Height) | 20 | Female | 31 | 1.414214 | 0.316228 | | ESS |
| CAG | 40 | Male | 859.7 | 124.2954 | 19.65283 | 7.198 | 0.0001 |
| (Calculated Area of Glenoid cavity) | 20 | Female | 651.35 | 48.8276 | 10.91818 | | ESS |

ESS- Extremely Statistically Significant

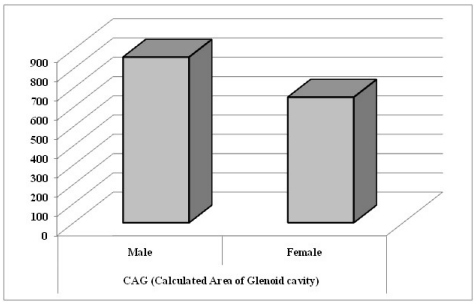
With the help of Microsoft Excel software, the logistical regression equation was derived from stepwise method which is shown in [Table 2]. By multiplying the value of each dimension with its corresponding coefficient (β coefficient) and adding the products together along with the appropriate constant (Intercept), the sex of a specimen can be determined. For the regression equation incorporating all for Scapular dimensions, the logistic regression score (Y) is calculated as follows. $Y= (0.0287 \times MSB) + (0.0481 \times MSH) + (0.0972 \times GCB) + (0.0776 \times GCH) + (- 0.0033 \times CAG) + -10.6425$ When the total score **(Y)** is Near 1(one) the bone belongs to male and when near 0(zero) bone belongs to female.

**Table 2:** Showing Stepwise function analysis for Logistic regression equation

| | β -Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept/ Constant | -10.64251962 | 1.65800243 | -6.41888058 | 0.00000004 | -13.9666 | -7.3184 | -13.9666 | -7.3184 |
| MSB | 0.02872384 | 0.00892317 | 3.21901898 | 0.00217802 | 0.0108 | 0.0466 | 0.0108 | 0.0466 |
| MSH | 0.04805042 | 0.00305860 | 15.70995741 | 0.00000000 | 0.0419 | 0.0542 | 0.0419 | 0.0542 |
| GCB | 0.09717543 | 0.07578838 | 1.28219436 | 0.20525180 | -0.0548 | 0.2491 | -0.0548 | 0.2491 |
| GCH | 0.07762853 | 0.04897396 | 1.58509820 | 0.11878341 | -0.0206 | 0.1758 | -0.0206 | 0.1758 |
| Calculated Area of GC (CAG) | -0.00332956 | 0.00208432 | -1.59743240 | 0.11600528 | -0.0075 | 0.0008 | -0.0075 | 0.0008 |




Graph 1:




Graph 2:

**Graph 1:** Showing Various male female comparison of mean of all Parameters calculated in millimetre

**Graph 2:** Showing male female comparison of mean of Calculated Area of Glenoid cavity(CAG) calculated in $mm^2$

## DISCUSSION

Previous studies suggested that use of multiple variables give higher accuracy compared to the studies using single variable. It has to be kept in mind that sometimes it is possible that all the measurements are not available if the scapula is not intact. The current study yielded that, accuracy of sex determination from scapula can be improved by deriving logistic regression score (Y) from 4 scapular measurements and Calculated Area of Glenoid cavity can be used as fifth parameter. Dabbs G. accurately reported sex of an individual using maximum length of scapula, maximum length of scapular spine, breadth of in fraspinous body, height and breadth of the Glenoid fossa.[8]P. James Macaluso Jr. Reported 88.3% success rate for area of the glenoid fossa and 85.8% success rate for glenoid fossa breadth.[9] Y Scoltz found >91% accuracy for female and >95% accuracy for male in his study.[10] Ozer reported 82.9% -95% accuracy with highest accuracy for maximum scapular breadth.[11] All four measurements showed high accuracy in sex determination of scapulae. Findings of this study are comparable to the findings of other studies utilizing the scapular measurements. This study confirmed that scapular measurements can accurately determine gender in Western Indian population, as well as successful in deriving population specific logistic regression formula for determination of sex from scapulae.

## CONCLUSION

The results of this study are very useful for sex determination inforensic anthropological and medicolegal cases where skull and pelvic bones are unavailable or damaged. The present study has confirmed that gender can be determined with high accuracy by use of scapular measurements. Accuracy of sex determination can be improved by obtaining logistic regression score (Y) from four scapular measurements (MSH, MSB, GCH and GCB). The present study confirmed that MSB alone as well as combination of all four parameters are good discriminators. In this study, population specific logistic regression formula is derived which is helpful for sex determination in Indians.

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