Morphometric Examination of Scapula to Determine Sexual Dimorphism

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Abstract

Background and Aim: Determining the sex of an individual is possible when we apply appropriate statistical methods using scapular measurements. Determination of sex using scapular measurements is very useful in medicolegal cases, natural disasters and in certain circumstances in which traditionally used bones of skeleton are either absent or fragmented. This study aims to assess sexual dimorphism for identification purposes.

Material and Methods: This study was conducted using 40 adult skeletons (25 males and 15 females) with closed epiphysis having intact and well-preserved scapulae. Scapulae were measured in millimetre for MSH, MSB, GCH and GCB with the help of the sliding calliper. For all tests, confidence level and level of significance were set at 95% and 5% respectively.

Results: There was a highly significant difference ($P < 0.001$) between male and female for the mean value of all measurements. So it indicates the existence of strong sexual dimorphism in scapula.

Conclusion: Geometric morphometrics techniques feature promising results in the evaluation of skeletal sexual dimorphism, including in the size and shape of the scapula. The results of this study are very useful for sex determination in forensic 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.

Key Words: Glenoid cavity, Medicolegal cases, Sexual dimorphism, Scapular measurements

Introduction

Sex estimation of unidentified human skeletal remains is fundamental to establish a biological profile, being a critical step on the identification process.[1,2] Traditionally, the evaluation of a biological profile (sex, population affinity, age at death, and stature) begins with sex assessment, as age at death and stature are sex-dependent.[3,4] The evaluation of biological sex on skeletal remains assumes the existence of phenotypic differences between female and male individuals. These differences can be observed for both size and shape and are affected by chromosomic structure and the expression of sexual hormones. The degree of sexual dimorphism is influenced by the biomechanical functions of certain skeletal elements, environmental factors, nutrition, and sexual selection, among others.[5-10]

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Sex estimation methodologies usually fall into two categories: morphological (visual) and metric.[11,12] Morphological methods consist of a visual assessment on dry bones and they are observer-dependent, which produces subjective results. Metric methods evaluate size differences between males and females, assuming that males are larger than females.[13,14] They are less observer-dependent and easier to assess and interpret. Both approaches tend to be influenced by geographic-specific constraints. Molecular methods, particularly proteomic and genomic analyses, are highly accurate but generally not easily available.[15]

Skull and pelvis are most frequently utilized for the sex determination. However, there is a disadvantage of using skulls and pelvis for sex determination as they do not provide reliable results when they are damaged. The other bones mentioned above are often missing or found incomplete during forensic examinations. Scapula is mostly obtained in intact condition compared to the other bones. Determining the sex of an individual is possible when we apply appropriate statistical methods using scapular measurements. Determination of sex using scapular measurements is very useful in medicolegal cases, natural disasters and in certain circumstances in which traditionally used bones of skeleton are either absent or fragmented.

Materials and Methods

This study was conducted using 40 adult skeletons (25 males and 15 females) with closed epiphysis having intact and well-preserved scapulae. These skeletons of known sexes were taken from Dept. Of Anatomy, Tertiary care Institute, India. Following parameters of scapula were measured with the help of sliding calliper. All measurements were taken in millimeter.

Maximum scapular height

Maximum distance between the highest point of the superior angle and the lowest point of the inferior angle.

Maximum scapular breadth

Maximum distance between the point on the longitudinal axis of the glenoid cavity and the point on the prolongation of the inferior boundary of the dorsal margin of the spine.

Glenoid cavity height

Maximum distance from the inferior point of the glenoid margin to the most prominent point of the supraglenoid tubercle.

Glenoid cavity breadth

Maximum breadth of the articular margin, perpendicular to the glenoid cavity height.

Statistical analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to data editor page of SPSS version 15 (SPSS Inc., Chicago, Illinois, USA). For all tests, confidence level and level of significance were set at 95% and 5% respectively.

Results

Table 1 shows mean of the MSH, MSB, GCH and GCB, their standard deviation, standard error mean, t-value and P value for both males and females. There was a highly significant difference ($P < 0.001$) between male and female for the mean value of all measurements. So it indicates the existence of strong sexual dimorphism in scapula.

Table 1: Descriptive statistics for the measurement of the MSH, MSB, GCH and GCB in Male and Female

Variable	Gender	N	Mean ±SD	P value
MSH	Male	50	135.25±10.54	0.001*
	Female	30	120.24±9.22	
MSB	Male	50	100.23±8.40	0.003*
	Female	30	94.36±5.14	

Variable	Gender	N	Mean ±SD	P value
GCH	Male	50	34.87±4.12	0.001*
	Female	30	31.47±5.10	
GCB	Male	50	23.54±4.65	0.05*
	Female	30	22.10±2.48	

* indicates statistically significance at p≤0.05
MSH=Maximum scapular height,
MSB=Maximum scapular breadth,
GCH=Glenoid cavity height,
GCB=Glenoid cavity breadth

Discussion

The human skeletal sexual dimorphism is expressed as differences in size and shape, with males presenting, in general, larger bones.[16,17] Sex differences observed on human bones, including the scapula, are influenced by genetic factors, hormonal stimuli during different stages of puberty, and socioeconomic and environmental factors, among others.[18,19] These factors vary significantly between geographic populations, leading to different degrees of sexual dimorphism in distinct populations. The scapular sexual differences can be expressed in both size and shape and these are significantly different between males and females in the studied sample. As observed in other bones, e.g[20,21] , the scapula from male individuals is usually larger. Traditional morphometric studies of the scapula also show that the human scapula displays sexual dimorphism in relation to size.[22,23]

After taking measurements of scapula described in materials and methods section, the resulting data of measurement was subjected to logistic regression analysis in order to develop population specific standards for sex determination as described in results section.[21] The derived regression equations yielded correct classification accuracy rates. Therefore, scapula is having a great importance in gender identification of unknown person in Indian population. As mentioned, among all the 4 parameters, scapular breadth was most significant. Dabbs G. reported 84 -88% accuracy using maximum length of scapula, maximum length of scapular spine, breadth of infraspinous body, height and breadth of the glenoid fossa.[24] P. James Macaluso Jr. Reported 88.3% success rate for area of the glenoid fossa and 85.8% success rate for glenoid fossa breadth.[25] Y Scoltz found >91% accuracy for female and >95% accuracy for male in his study.[26] Ozer reported 82.9% -95% accuracy with highest accuracy for maximum scapular breadth.[27]

Previous studies suggested that use of multiple variables give higher accuracy compared to the studies using single variable. The formula obtained using four variables (MSH, MSB, GCH, GCB) was highly reliable. 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. Because the mean scapular breadth measurements show highest accuracy rates amongst all the four parameters measured in the study, it may be having a great importance considering scapula an easily fragmented bone. It is to mention that MSB showed more reliable values over other parameters. The current study yielded that, accuracy of sex determination from scapula can be improved by deriving logistic regression score (Y) from 4 scapular measurements. Among the four measurements, MSB is the most significant parameter. Findings of this study are comparable to the findings of other studies utilizing the scapular measurements. This study confirmed that scapula has high value of accuracy to determine gender in Indians.

Conclusion

Geometric morphometrics techniques feature promising results in the evaluation of skeletal sexual dimorphism, including in the size and shape of the scapula. The results of this study are very useful for sex determination in forensic 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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Conflict of Interest – none declared

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