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Original communication

Sex determination in a contemporary Mexican population using the scapula☆

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ABSTRACT

The scapula is useful for sex determination in human skeletons. Muscles provide protection to the scapula making it difficult to fracture, therefore increasing the potential for undamaged scapulae at forensic scenes. The goal of this project is to evaluate the accuracy of discriminant functions, created using an indigenous Guatemalan population when applied to a contemporary Mexican sample for determination of sex from the scapula. The length of the glenoid cavity (LGC) and breadth of the glenoid cavity (BGC) were measured. The sample included 177 individuals (101 males and 76 females) with age ranges from 21 to 100 years old. When the Guatemalan discriminant functions were applied to the Mexican sample they showed high accuracy rates for sexing male scapulae (100%) and low accuracy rates for sexing female scapulae (48.68%–51.32%). Size comparisons were made to an indigenous Guatemalan sample and a contemporary White sample. Overall, LGC and BGC were larger in the Mexican sample than in the Guatemalan sample but LGC and BGC were smaller in the Mexican sample than in the White sample. Population-specific discriminant functions were created for the Mexican population with an overall sex classification accuracy rate of 83.6%–89.3%.

1. Introduction

South and Central America are scattered with the bones of civil conflict. In the past 30 years, the United Nations has handled more than 51,000 cases of enforced disappearance with thousands of more individuals who remain unidentified in mass graves.[1] Accurate sex determination techniques for human skeletal remains are necessary to aid in the identification of these missing individuals. However, many of the techniques utilized by forensic anthropologists were developed using non-Latin American populations.

Discriminant function equations for sex determination have been shown to be population specific.[2,3] Even within small geographic areas researchers have found variation in sexual dimorphism requiring the development of population-specific discriminant function equations.[4–6] Currently, the only scapular discriminant function equations available for the determination of sex for a Latin American population are those developed from an indigenous Guatemalan population.[7] The accuracy of these functions ranged from 89.2% to 94.6% for correct sex identification.[7]

In 1894, Dwight demonstrated that maximum scapular length and glenoid cavity were useful indicators of sex.[8] The infraspinous and supraspinous fossa of the scapula are more commonly eroded due to taphonomic processes but the spine and the glenoid cavity are often available for forensic analyses.[9,10] Scapular muscle attachments provide protection to the bone making it difficult to fracture or break.[11] The goals of this project are to (1) apply the indigenous Guatemalan scapular discriminant functions to a contemporary Mexican population and, (2) develop population specific discriminant function equations for sexing skeletons from a contemporary Mexican population.

2. Materials and methods

This research utilized 177 individuals (101 males and 76 females) from the Laboratorio de Antropologia Fisica Departamento de Anatomia, which is housed within the Faculty of Medicine at the

☆ This research has not been presented at any meetings or conferences.

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Universidad Nacional Autonoma de Mexico (UNAM), Mexico City. The collection consists of 237 documented skeletons, i.e. sex, age at death, occupation, and cause of death. The individuals ranged in age from 21 to 100 years old. This is a growing collection as new skeletons are obtained from individuals or family members who wish to donate their body or the remains of their family member for scientific research. This collection is composed of individuals representing a contemporary Mexican population because all of the individuals lived during the twentieth and twenty-first centuries.

Following the protocol of Frutos (2002), the length of the left glenoid cavity (LGC) and breadth of the left glenoid cavity (BGC) were recorded using a standard Vernier caliper to the nearest 1/100 of a millimeter (Table 1, Figs. 1 and 2). A comparison of the measurements taken from 34 paired scapulae showed no statistically significant side differences with all $p > 0.05$. Therefore only the left scapula was measured. In cases where the left scapula showed evidence of trauma, damage, pathological changes or was absent measurements were taken using the right scapula. Intra- and inter-observer rates were calculated by re-measuring 20 randomly selected scapulae (10 males and 10 females) for each measurement variable. There were two observers. The measurements between observers were collected one week apart.

All statistical analyses were performed with the SPSS (version 22.0) software program with a level of significance $\alpha = 0.05$. Parametric (normally distributed) data were analyzed using a paired t-test and non-parametric (not normally distributed) data were analyzed using a paired Wilcoxon test. Descriptive statistics were obtained for each measurement. Males and females were analyzed separately. Using a two sample t-test for the parametric data and a Mann–Whitney U test for the non-parametric data the mean values of the two measurements were compared between the sexes to determine if statistically significant differences existed. The contemporary Mexican scapulae measurements were compared with other populations using two sample t-tests: indigenous Guatemalans[7] and contemporary Whites.[12] The indigenous Guatemalan[7] discriminant functions were applied to the contemporary Mexican sample to determine their accuracy for sex classification. Population-specific discriminant functions were created for the contemporary Mexican population.

All data were tested for normality. The LGC and BGC measurements were separated into groups (i.e. male and female) to ensure that each sex was accurately represented. The Kolmogorov–Smirnov (KS) test was used to evaluate normality of the data with a significance level of $\alpha = 0.05$. For males, the LGC and BGC measurements were normally distributed. For females, the LGC measurements were not normally distributed but the BGC measurements were normally distributed.

3. Results

3.1. Intra- and inter-observer error rates

When examining intra-observer error rates, there were no significant differences between the LGC and BGC measurements ($p > 0.05$). However, for the inter-observer error rates the LGC measurement did not differ significantly between observers ($p > 0.05$) but the BGC measurement displayed significant differences ($p = 0.03$) (Table 2).

Table 1
Description of measurements.

Measurement	Description[a]
Length of glenoid cavity of the scapula (LGC)	Maximum distance across glenoid cavity perpendicular to anterior–posterior axis
Breadth of the glenoid cavity of the scapula (BGC)	Maximum distance across glenoid cavity measured at a right angle to axis of length of glenoid cavity

[a] Modified from Frutos 2002.

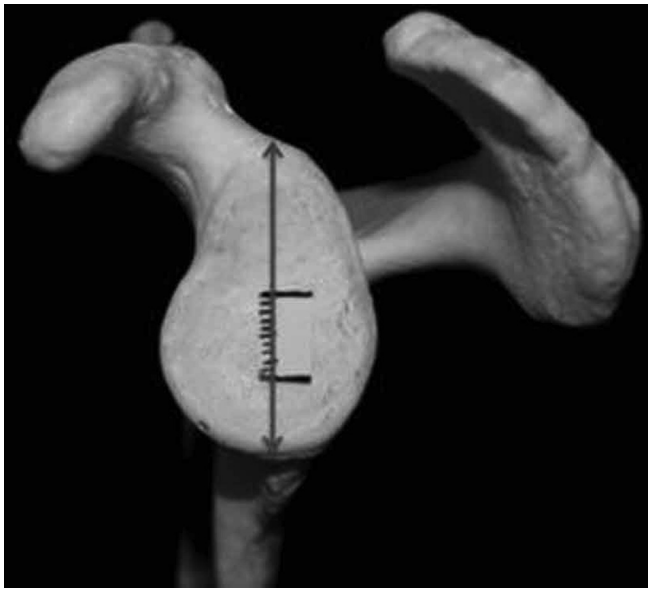

Fig. 1. Length of the glenoid cavity measurement.

3.2. Assessment of sexual dimorphism

Table 3 displays the descriptive statistics and shows the results for the assessment of sexual dimorphism for the contemporary Mexican sample. The LGC and BGC are larger in the male scapulae than the female scapulae. Both p-values are less than 0.05 indicating that both the LGC and BGC measurements were sexually dimorphic in the contemporary Mexican sample.

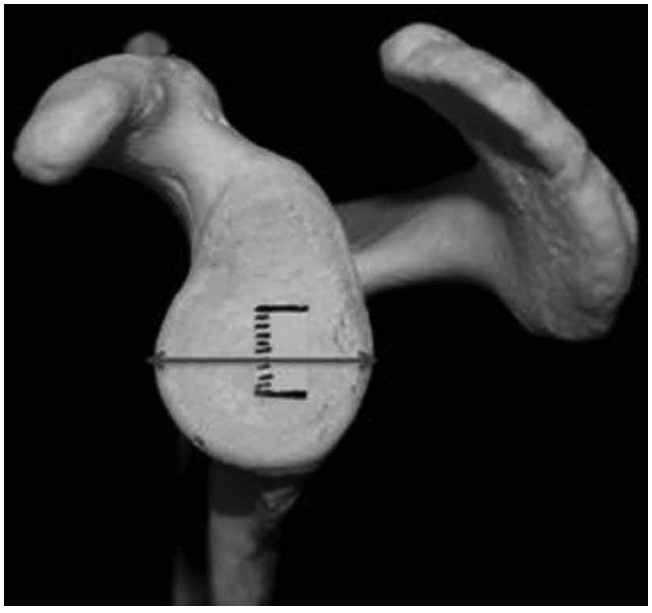

Fig. 2. Breadth of the glenoid cavity measurement.