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Determination of sex from the patella in a contemporary Spanish population☆

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ABSTRACT

The skull and pelvis have been used for the determination of sex for unknown human remains. However, in forensic cases where skeletal remains often exhibit postmortem damage and taphonomic changes the patella may be used for the determination of sex as it is a preservationally favoured bone. The goal of the present research was to derive discriminant function equations from the patella for estimation of sex from a contemporary Spanish population. Six parameters were measured on 106 individuals (55 males and 51 females), ranging in age from 22 to 85 years old, from the Granada Osteological Collection. The statistical analyses showed that all variables were sexually dimorphic. Discriminant function score equations were generated for use in sex determination. The overall accuracy of sex classification ranged from 75.2% to 84.8% for the direct method and 75.5%–83.8% for the stepwise method. When the South African White discriminant functions were applied to the Spanish sample they showed high accuracy rates for sexing female patellae (90%–95.9%) and low accuracy rates for sexing male patellae (52.7%–58.2%). When the South African Black discriminant functions were applied to the Spanish sample they showed high accuracy rates for sexing male patellae (90.9%) and low accuracy rates for sexing female patellae (70%–75.5%). The patella was shown to be useful for sex determination in the contemporary Spanish population.

1. Introduction

The patella, from the Latin for “small plate”, is a flat, inverted triangular bone situated on the front of the knee-joint.[1] In humans, the patella is the largest sesamoid bone in the body. It articulates with the femur and covers and protects the anterior articular surface of the knee joint. The patella develops in the tendon of the quadriceps femoris muscle and is ossified from a single center. Infants are born with a patella of soft cartilage, which begins to ossify around 2–3 years of age.[1] The patella functions primarily as an anatomic pulley for the quadriceps muscle. It increases the lever arm of the extensor mechanism allowing for more effective knee flexion and thus increasing quadriceps strength by 33%–50%.[1] The patella has also been shown to be resistant to postmortem and taphonomic changes and is therefore useful for the determination of sex in unknown human remains.[2]

Within forensic anthropology there is a need to find accurate and reliable methodologies to assist with the determination of sex for unknown human remains. The determination of sex an important part of the biological profile as it provides for a better understanding of other elements of the biological profile as the determination of stature and age at death are sex dependent. The determination of sex is more reliable when a full skeleton is available for analyses. However, incomplete or fragmentary human remains are often found during a forensic recovery especially in cases of mass disasters and human rights investigations. When complete or fragmentary remains are found, forensic anthropologists utilize both morphological and metric methods for the determination of sex. Morphological methods, however, are subjective and accuracy is dependent on observer experience whereas metric methods use statistical analyses to objectively validate results.[3]

The most commonly used metric method for sex determination

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is discriminant function analysis.[4] Discriminant function equations for sex determination have been shown to be population specific.[5,6] Even within small geographic areas variation in sexual dimorphism has been found therefore requiring the development of population-specific discriminant function equations.[7–9] Currently, there are no patellar discriminant function equations available for the determination of sex for a Spanish population. The goals of this research are to (1) test the accuracy of discriminant functions developed on a White[10] and Black[11] South African population for use with a contemporary Spanish population for determining sex from the patella, and (2) develop population specific discriminant function equations for the patella from a contemporary Spanish population. The White[10] and Black[11] South African data were used as they were the only published discriminant functions available for comparison that employed the same variables as the current research.

2. Materials and methods

This study used 106 individuals (55 males and 51 females) of a contemporary Spanish population from the Granada Osteological Collection, housed in the Laboratory of Anthropology, Faculty of Medicine, at the University of Granada, Spain. Age at death ranged between 22 and 85 years of age. Demographic information was known for each individual, i.e. sex, year of birth, age at death. The mid-twentieth Century skeletal collection consists of a comprehensive assemblage of complete and partial skeletal remains from the San Jose Municipal Cemetery in Granada, Spain. The Granada Osteological Collection represents a contemporary Spanish population.

Following the protocol of Dayal and Bidmos[11], six variables from the patella were recorded using a standard Vernier caliper to the nearest 1/100 of a millimeter (Table 1, Figs. 1–3). A comparison of the measurements taken from 20 paired patellae showed no statistically significant side differences with all $p > 0.05$. Therefore only the left patella was measured. In cases where the left patella showed evidence of trauma, damage, pathological changes or was absent measurements of the right patella were recorded. Intra-observer error rates were calculated by re-measuring 30 randomly selected patellae (15 males and 15 females) for each measurement variable. Inter-observer error rates were calculated by re-measuring 20 randomly selected patellae (10 males and 10 females) for each measurement variable. These sample sizes are appropriate as previous studies have shown that a subsample of 10%–20% of the total population should be used to test for intra-observer and inter-observer error.[12] There were two observers. The intra- and inter-observer measurements were collected one week apart (see Fig. 3).

All statistical analyses were performed with the SPSS (version 22.0) software program with a level of significance $\alpha = 0.05$ and Bonferonni-adjusted level of significance $\alpha = 0.008$. 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 six measurements were compared between the sexes to determine if statistically significant differences existed. The

Table 1
Description of measurements.

Measurement	Description[a]
Maximum height (MAXH)	Greatest distance between the base and the apex.
Maximum breadth (MAXB)	Greatest distance between the medial and the lateral sides.
Maximum thickness (MAXT)	Greatest distance between the anterior and the posterior sides.
Lateral articular facet breadth (LAFB)	Distance between the lateral edge of patella and the median ridge of articular facet.
Height of articular facet (HAF)	Maximum height of articular facet on the posterior aspect of the patella.
Medial articular facet breadth (MAFB)	Distance between the medial edge of patella and the median ridge of articular facet.

[a] (Modified from Dayal and Bidmos[11]).

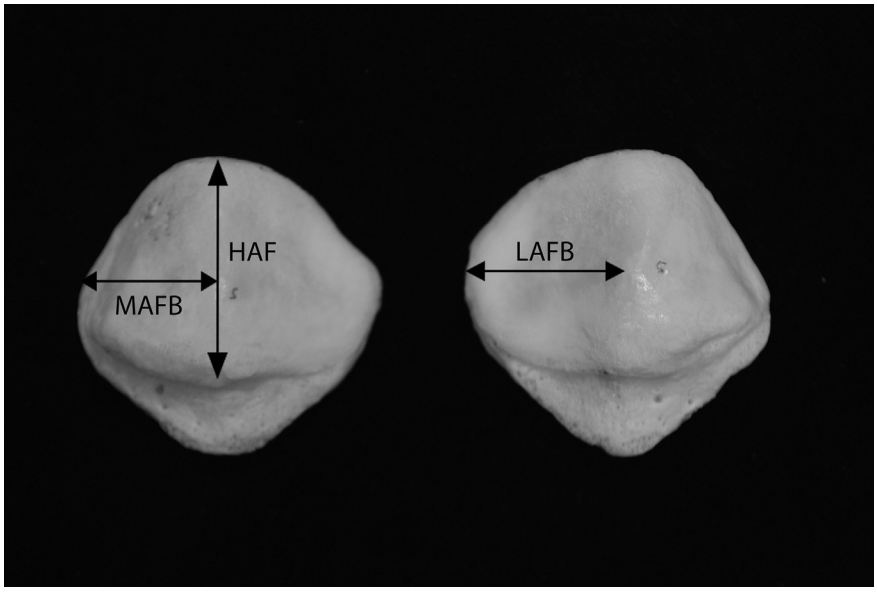

Fig. 1. Patellar measurements: lateral articular facet breadth (LAFB), height of articular facet (HAF), medial articular facet breadth (MAFB) (photo by A. Rozendaal).