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Original Communication

Sexing of human hip bones of Indian origin by discriminant function analysis

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Abstract

The present study was carried out in terms of discriminant analysis and was conducted on 100 human hip bones (of unknown sex) of Indian origin. Based on morphological features, each of the hip bone was rated on a scale of 1–3 for sexing. Twelve measurements and five indices were recorded. The results of discriminant function analysis showed that the acetabular height (vertical diameter) and indices 1 (total pelvic height/acetabular height), 2 (midpubic width/acetabular height) and 3 (pubic length/acetabular height) were very good measures for discriminating sexes. Pelvic brim depth, minimum width of ischiopubic ramus and indices 4 (pelvic brim chord × pelvic brim depth) and 5 (pubic length × 100/ischial length) were also good discriminators of sex. The remaining parameters were not significant as they showed a lot of overlap between male and female categories. The results indicated that one exclusive criterion for sexing was index 3 (pubic length/acetabular height). In comparison with the morphological criteria, the abovementioned index caused 25% and 10.25% increase in the hip bones of female and male category, respectively.

Keywords: Hip bone; Sex estimation; Discriminant function analysis; Physical anthropology

1. Introduction

The four main features of biological identity are sex, age, stature and ethnic background. A reliable estimation of sex from the skeleton by using various criteria is important while dealing with undocumented skeletal material, whether it is in the field of medicine or work with prehistoric osteological collections. It is well known that skeletal characteristics vary among populations, therefore each population should have specific standards to optimize the accuracy of identification. Although many bones of the skeleton present size related sexual differences, those of the pelvis usually display marked sex differences in morphology independent of size due to different reproductive functions mainly influenced by sex hormones.[1] The distinctive morphology of the human hip bone and its clear sexual dimorphism makes it of interest from anatomical, anthropological and forensic points of view. It can therefore be a reliable criterion for estimation of sex of skeletal remains under study.

Methods of determining the sex of an individual based upon skeletal remains can be divided into three broad categories.

The first category is of visual criteria, based on morphological or subjective observations like subpubic angle, sciatic notch, preauricular sulcus, auricular area etc. As a general rule, male bones are larger and heavier than female ones,[2] but there may be an overlap of ranges of variation of male and female bones based on these features, therefore their accuracy depends upon the experience of researchers.[1]

The second category for sexing of the hip bones is based on the measurements or metric techniques e.g. ischiopubic index, pubic angle, pubic length etc.[3–6] The major problem however is that this method requires most of the bone to be intact and the measurements and indices thus calculated have to be compared with a chart of male and female

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values which is very time consuming, especially when a whole series of skeletons are under study.

The third category of methods utilized for sex determination of skeletal remains is discriminant function analysis, a concept first introduced by Fisher in anthropology.[7–9] This method has the practical advantage of permitting sexual assessment of poorly preserved remains. However little work has been undertaken using this method in Indian population. To compensate for this paucity of information, sexing of hip bones by discriminant function analysis was undertaken in the present study.

2. Materials and methods

The study was conducted in the Department of Anatomy, Lady Hardinge Medical College, New Delhi on 100 dry adult human hip bones of unknown sex without any congenital or iatrogenic deformity. The hip bones obtained were a part of osteological collection of the medical colleges of Delhi. Measurements were taken with the help of Vernier calipers, metallic scale and goniometer.

The procedure for determination of sex was carried out as follows:

2.1. Morphological sexing

This was based on observations of experienced anatomists of our department. The following nine morphological features were used for sex determination:

- Preauricular sulcus.[10]
- Greater sciatic notch.[10]
- Obturator foramen.[10]
- Iliac fossa.[10]
- Comparison between diameter of acetabulum and the distance of its anterior rim from pubic symphysis.[10]
- Ischiopubic ramus eversion.[10]
- Ventral arc.[11]
- Subpubic concavity.[11]
- Ridge on medial aspect of ischiopubic ramus.[11]

Based on the above morphological features (Table 1), each hip bone was classified in three categories for sexing namely male, female and indeterminate.

2.2. Metric sexing

This was done by measuring the following 12 parameters of the hip bone. The measurements were done to the nearest tenth of a millimeter using vernier calipers and a metallic scale and the pubic angle was measured by using a goniometer (Figs. 1–4).

- *Total pelvic height*. The longest hip bone dimension, measured from the highest point on the iliac crest to the deepest point of ischial tuberosity (inferior most point on iliac tuberosity).[12]

Table 1
Differences in morphological traits in male and female hip bones

Trait	Male expression (−)	Female expression (+)
Preauricular sulcus	Absent	Present
Greater sciatic notch		
(a) Posterior angle	Narrow	Wide
(b) Width	Narrow	Broad
Obturator foramen's shape	Oval	Triangular
Iliac fossa	Shallow	Deep
Acetabulum		
(a) Diameter	Wide	Narrow
(b) Distance of the anterior rim of acetabulum from pubic symphysis vis-à-vis diameter	Less	More
Ischiopubic ramus eversion	Present	Absent
Ventral arc on body of pubis	Absent	Present
Subpubic concavity	Absent	Present
Ridge on the medial aspect of ischial tuberosity extending to ischiopubic ramus	Absent	Present

- *Pelvic (iliac) width*. It was measured as straight distance from anterior superior iliac spine to posterior superior iliac spine.[13]
- *Acetabular height (diameter)*. It was taken as the diameter of acetabulum measured along the axis of the body of ischium.[13]
- *Midpubic width*. It was measured as the shortest distance from the midpoint of pubic symphysis to the nearest obturator foramen margin.[13]
- *Pubic length*. It was taken as straight distance from the mid point of acetabulum (from dorsal aspect, the point where the three elements forming the hip bone meet) to the uppermost margin of pubic symphyseal surface.[14]
- *Pelvic brim chord*. It was measured as the straight distance from the auricular point (defined as intersection of arcuate line with anterior edge of auricular surface) to the uppermost edge of pubic symphyseal surface.[13]
- *Pelvic brim depth*. It was taken as the perpendicular distance from the midpoint of pelvic brim chord to the pelvic brim.[13]
- *Minimum pubic width*. It was defined as the least straight distance from pubic symphyseal surface to the nearest obturator foramen margin.[15]
- *Pubic angle (inter-rami angle)*. It was measured as the angle formed between the long axis of superior and inferior ramus of pubis.[15]
- *Minimum width of ischiopubic ramus*. It was measured as the least straight distance between the ischiopubic ramus and nearest obturator foramen margin.[15]
- *Acetabular symphyseal breadth*. It was measured as the straight distance between the outermost point of the posterior margin of acetabulum and the midpoint of pubic symphyseal surface.[16]
- *Ischial length*. It was measured as the distance from the anterior most edge of the body of ischium to the midpoint of acetabulum (from dorsal aspect, point in the acetabulum where the three elements forming the hip bone meet).[14]