SEX DETERMINATION OF HUMAN HIP BONES BY DISCRIMINANT FUNCTION ANALYSIS BY USING ISCHIOPUBIC INDEX

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ABSTRACT

Background: The four characteristic features for biological identification are sex, age, ethnic background, and stature. Accurate methods of sex estimation from the human skeleton by using various criteria are important while dealing with the undocumented human skeletal material. There are many methods of sex estimation that can be implied to the human skeleton. Methods are varying from visual assessments to metric analyses for sexually dimorphic traits. **Material &Methods**: The study had been conducted in the Department of Anatomy, S.P. Medical College, Bikaner and Other Medical Colleges of Rajasthan on 200dry adult human hip bones having no deformity or fracture. Ischio-pubic index = Pubic length X 100 / Ischial length was used for sex determination. **Results:** Mean differences of the ischiopubic index was highly significant between definite male and definite female with P-value is <0.001. The ischial length was also shown significant difference P - the value of 0.0521. Between definite male and probably female, mean differences of the ischiopubic index was highly significant P-value <0.001. Pubic length (P=0.0412) was also showed a significant difference between definite male and probably male. Between definite male and don't know, ischiopubic index (P=0.009) showed a significant difference. Between probable male and definite female, ischiopubic index (P=< 0.00032) was highly significant. Between a definite female and probably female, ischiopubic index (P=0.0019) showed the significant mean difference. **Conclusion:** We concluded from the present study that the single best parameter found by discriminant function analysis in the present study is ischiopubic index. But still, there was considerable overlapping in the range.

Keywords:pubic length, ischial length, ischiopubic index.

INTRODUCTION

The four characteristic features for biological identification are sex, age, ethnic background,and stature. Accurate methods of sex estimation from the human skeleton by using various criteria are important while dealing with the undocumented human skeletal material. There are many methods of sex estimation that can be implied to the human skeleton. Methods are varyingfrom visual

assessments to metric analyses for sexually dimorphic traits **(1)**.

Methods are also varying in the elements used, many studies of the human skeleton bones have been analysed to assess the degree of the sexual dimorphism and accuracy of the sex estimation. In these studies, some elements have proved to be more reliable than others. A lot of research has been done

and huge literature is available in anatomy for identification of human skeleton **(2)**.

Nearly every index and parameters of the human skeleton have been used to develop methods for estimation of sexwith varying degrees of outcomes. The general anatomical areas used for sex determination are the pelvic girdle, the skull, and long bones, although many other bones have also been researched. The pelvic girdle is the most accurate bone from which to determine sex and methods using these elements tend to make accurate predictions in 90 to 95 percent of individuals**(3)**. Sexual dimorphism in human skeleton is mostly due to the changes that occur over adolescence to meet the requirements of childbirth in females. The female pelvis grows more in width than height during adolescence, while the growth of the male pelvis maintains the morphological characteristics of both sexes before adolescence.

Thus, a wide pelvic inlet, wide subpubic concavity, and a wide greater sciatic notch are the hallmarks of the female pelvis, while the opposite characteristics are found in the malepelvis **(4)**. Methods of determining the sex of an individual rooted upon skeleton bones can be classified into three broad categories. The first category is of visual criteria, which are based on morphological and subjective observation.

But there may be an overlap of ranges of variation of male and female bones based on sexual features. This may cause difficulty or even impossibility of definite sex determination. The second category for sex estimation of the hip bones is focused on the measurements or objective techniques.

These methods are easier to teach and are more reliable than morphological assessments. The third category of sex determination methods utilized for the skeletal remains is discriminant function analysis. The basic theory for discriminant function analysis was discovered by Fisher. This method has the practical advantage in being superior inthe sexual assessment of even poorly preserved remains**(5)**.

The methods of determining the sex of skeletons are not perfect and constant efforts are being made to improve them. So a method of sex determination of human skeleton by discriminant function analysis has been undertaken for the present study.

MATERIALS & METHODS

The study had been conducted in the department of anatomy ,S.P. Medical College, Bikaner and Other Medical Colleges of Rajasthan on 200dry adult human hip bones having no deformity or fracture. This was based on side determination and observations of hip bones and nine morphological features of each bone which thereafter rated on a scale of 1-9 for sexing. Preauricular sulcus, Greater sciatic notch, Obturator foramen, Iliac fossa, pubic symphysis, Ischiopubic ramus eversion, Ventral arc, Subpubic concavity, Ridge on the medial aspect of ischiopubic ramus. Objective sexing was done by measuring twelve features on the hip bone.

The measurements were done to the nearest tenth of a millimetreusingverniercalipers, osctometric board and a metallic scale. The pubic angle was measured by using a goniometer. Total pelvic height, Pelvic (iliac) width, Ace tabular height (diameter), Mid-pubicwidth, Pubic length, Pelvic brim chord, Pelvic brim depth, Minimum pubic width, Pubic angle (inter-rami angle), Minimum width of ischiopubicramus, Acetabularsymphyseal breadth and Ischial length were defined.

Ischio-pubicindex = Pubic length X 100 / Ischial length wasused for sex determination.The measurements were subjected to statistical analysis i.e. Univariate, bivariate, and multivariate analysis using were analyzed using MS Excel 2010, Epi Info v7 and SPSS v22.

RESULTS

The study included 200 intact human hip bones. Side determination of each of them was done and these were classified into five categories according to nine morphological features.

Table 1 shows grouping of hip bones into five categories (Definite male, Probable male, Don't Know, Probable Female and Definite Female) by using the visual criteria. Table 2 shows Means, Standard Deviation (SD), Standard error, range and P-value of the measurement using ANOVA F test. Univariate statistics of all the parameters showed that mean value of Total pelvic height and Ischial length was higher in males. Mean values of ischiopubic index was higher in females than in males.

Table no. 1:classification of hip bones by using the visual criteria

CATEGORY	NUMBER OF BONES		PERCENTAGE
	RIGHT	LEFT	
Definite male	26	24	25%
Probable male	33	37	35%
Don't know	21	29	25%
Probable female	10	10	10%
Definite female	05	05	05%

Table no. 2:measurement of hip bones using anova f-test

		Pubic length	Ischial length	Ischiopubic index
Definite Male	Mean	7.19	8.45	85.12
	S.D	0.40	0.48	3.80
.	S.E	0.06	0.07	0.54
	Range	5.99-7.89	7.32-9.42	77.69-95.82
Definite Female	Mean	7.13	7.41	96.26
	S.D	0.34	0.35	2.67
	S.E	0.11	0.11	0.85
	Range	6.71-7.68	6.81-7.91	92.05-99.18
P- value		0.10412	0.736	0.575

Table 3 shows the P value for the parameters with statistically significant differences of means relating to sex after applying Fisher LSD test using statistic

computersoftware. Mean differences of ischiopubic index was highly significant between definite male and definite female with P-value is <0.001.

Ischiallength was also shows significant difference P – valueof 0.0521. Between definite male and probable female, mean differences of ischio-pubicindex was highly significant P-value <0.001. Pubic length (P=0.0412) was also showed significant difference between definite male and probable male.

Between definite male and don't know, ischiopubic index (P=0.009) showed significant difference. Between probable male and definite female, ischiopubic index

(P=< 0.00032) was highly significant. Between definite female and probable female, ischiopubic index (P=0.0019) showed significant mean difference.

By applying bivariate statistic using Karl Pearson correlation coefficients and P values of measurements it was found thatIschial length showed significant positive correlation with pubic length and significant negative correlation with ischiopubic index. Pubic length showed highly significant positive correlation with all the measurements.

By applying multivariate statisticsANOVA test performed on each and every variance and the p-value of significance has been derived for all the variance. Ischio-pubic index was found to be the most discriminator criteria for sexingwith 76.66 % accuracy.

Table no. 3: p-values of mean differences after multiple comparisons using fisher test

	Pubic length		Ischial length		Ischio-pubic index	
	mean difference	p-value	mean difference	p-value	mean difference	p-value
DEFINITIVE MALE V/S DEFINITIVE FEMALE	0.0574	0.0432	1.0420	0.0521	-11.1328	0.0001
DEFINITIVE MALE V/S PROBABLE FEMALE	0.1384	0.0412	0.4975	0.0612	-3.8576	0.0052
DEFINITIVE MALE V/S PROBABLE MALE	0.0141	0.2140	0.0710	0.6021	-0.5074	0.7250
PROBABLE MALE V/S DEFINITIVE FEMALE	0.0433	0.6231	0.9710	0.0512	-10.6255	0.0003
PROBABLE MALE V/S PROBABLE FEMALE	0.1243	0.0562	0.4265	0.0623	-3.3502	0.0057
PROBABLE FEMALE V/S DEFINITIVE FEMALE	-0.0810	0.3120	0.5445	0.0591	-7.2753	0.0019

DISCUSSION

The present study involved 200 human hip bones, of which 170 are of unknown sex. The bones were grouped into 5 categories on the basis of 9 morphological criteria. It has been observedin various studies in the previous years that these 9 visual criteria are very useful in sexing of hip bones and hence the same were considered in the present study.

A study conducted by Phenice and he developed a visual method of sexing by working on os-pubis of bones known sex based on three criteria namely ventral arc, subpubic concavity and ridge on medial aspect of ischiopubic ramus (6). This method was used by Lovell with an accuracy of 83% (7). The visual criteria used in the present study were comparable to those used by above mentioned authors whose studies were based on bones of known sex.

These authors classified the bones into three categories i.e. male and female and those which could not be classified into these two, were put in an indeterminate group. Whereas in the present study, the male and the female categories were further divided into, a definite and a probable group which were increased the reliability of this study. We considered two measurements and one index and subjected them to uni-, bi- and multivariate analysis.

After getting the most discriminant factors we subjected them to discriminant function analysis and got 2 constant and the cut off value to categorize these bones into male and female. We got 79 female and 121 males' bones with accuracy of 76.66%. Our study showed that the means of pubic length were similar in males and females and no significance of sex differences found.

Milne, Patriquin et al also observed no significant differences in means of the sexes for pubic length, a finding similar to our study (8). The means of ischial length were found to be greater in males than females by Patriquin et al, and Theimeobserved a finding similar to that of our study (9). The present study showed thatischio-pubic index, using the above two parameters had significantly higher mean values for females than males.

It was similar to the findings of Bruzek and Davivong. Bruzek estimated the sex of71% of French and Portuguese males, and among females the pubis was relatively longer in 87% of cases in French series but only in 78% of cases in the Coimbrasample(10).

He concluded that this index was suitable as a preliminary indicator of the sex and it, together with the other characters contributed to an accurate evaluation of sexual dimorphism of the hipbone. Davivongs suggested that this index had a higher value for sex determination as the male and female

ranges of variation of this index showed a very small overlap **(11)**.

Results of Pal et al indicated that although statistically significant differences for this index were high, it was not reliable for sexing when subjected to further analysis**(12)**. Washburn found that the ischiopubic index was higher in females by approximately 16% while in our study it was 7% higher in females**(13)**. In another study he found that this index alone could sex over 90% of skeletons provided they belonged to one major racial group as he found considerable overlapping between White males and Negro females**(14)**.

Ischiopubicindex (pubic length X 100/ ischial length) displayed positive correlation with all pubic bone parameters as pubic length was used in the numerator. The results of discriminant function estimation showed that ischiopubic index was bestparameter for discriminating sexes. Ischial length was also good discriminator of sex.

Our findings of indices analysis was nearly similar with the results of Milne, who also worked on human bones of unknown sex**(15)**. Murphy, who worked based on New Zealand Polynesian skeleton, had similar findings **(16)**. This was also supported by Patriquin et al**(17)**. Ischial length was found to be a most significantly useful parameter by Patriquin et al and which was similar to the findings of our study**(17)**.

The single best parameter found by discriminant function analysis in present study isischiopubicindex. But still there was considerable overlapping in the range.

CONCLUSION

We concluded from the present study that the single best parameter found by discriminant function analysis in present study is ischiopubic index. But still there was considerable overlapping in the range. Along with it ischial length wasalso good discriminators of sex.

Therefore it can be concluded that the pubic part of the hip bone showed extreme sexual differentiation by ischiopubic index with 76.66% accuracy.

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