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SEX DETERMINATION OF HUMAN HIP BONES BY DISCRIMINANT FUNCTION ANALYSIS BY USING TOTAL PELVIC HEIGHT AND ACETABULAR HEIGHT

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ABSTRACT

Background: Methods of sex determination of an individual based upon skeleton can classified into three main categories visual criteria, measurements or objective techniques and discriminant function analysis. The methods of sex determination of skeletons are not accurate and constant efforts are being timely to improve them. Hence, we conduct the present study for sex determination of human hip bones by discriminant function analysis. **Material & Methods:** The present study was been conducted in the department of Anatomy, S.P. Medical College, Bikaner and Other Medical Colleges of Rajasthan. 200 dry adult human hip bones presenting with no deformity or fracture were selected for the study. Total pelvic height and Acetabular height (diameter) were measured and defined. Our study index was defined as = Total pelvic height / acetabular height (diameter) and used for sex determination and discriminant function analysis. **Results:** Mean differences of acetabular height was highly significant between definite male and definite female with P-value is <0.001. Total pelvic height and our study index were also shows significant difference P –values of 0.0417 and 0.005 respectively. Between definite male and probable female, mean differences of total Pelvic height, acetabular height and study index were non-significant. Total Pelvic height, acetabular height and study index were also showed non-significant difference between definite male and probable male also same results with definite male and don't know. Between probable male and definite female, Acetabular height. (P=<0.0012) and our study index (P-0.001) were highly significant. Between definite female and don't know, mean differences of acetabular height (P=< 0.0030) and our study index (P=0.0057) were highly significant. **Conclusion:** We concluded from the present study that the single best variable found by discriminant function analysis in our study is Acetabular height. But still there was considerable overlapping in the range. Along with it total pelvic height was also good discriminators of sex. We found our study index (total pelvic height/acetabular height) to be non-significant for sexing. Therefore, it should not be use for sexual differentiation.

Key words: Total pelvic height,Acetabular height, discriminant function analysis.

INTRODUCTION

The four most characteristic features of biological identity are sex, age, stature and ethnic background. The most accurate estimation of sex from the skeleton by using various criteria is

important while dealing with not having the appropriate legal documented skeletal material **(1)**. There are many sex determination methods that can be applied to human skeleton. Methods vary from visual sex determination methods to metric assessments of sexually dimorphic traits **(2)**.

Methods also differ in the elements which were used, previous studies of the human skeleton had been analysed to assess the range of sexual dimorphism and accuracy in sex determination. In these researches some parameters have proven to be more accurate than others **(3)**. Lot of research has been done and vast literature is available in human anatomy for identification of sex of human skeleton **(4)**.

Nearly every segment and fragment of the skeleton has been used in various methods for sex estimation with diverge degrees of significance. The most common anatomical regions used for sex estimation were the skull, the pelvic girdle and long bones, although other bones had also been utilized **(5)**. The pelvic girdle is the most unambiguous area from which to sex estimation and methods using these elements tend to make successful prognostication in 90 to 95 per cent of bones **(6)**.

Sexual dimorphism in human skeleton is mainly due to the growth changes that occur during adolescence to meet the requirements for the childbirth in females. The female pelvis changes more in width than height during adolescence, while the changes in the male pelvis tends to remain the morphological features of both sexes before adolescence.

Thus, a wide pelvic inlet, wide subpubic concavity and a wide greater sciatic notch are the characteristics of the female pelvis, while the divergent characteristics are observed in male pelvis **(7)**. Methods of sex determination of an individual based upon skeleton bones can be classified into three main categories. First category belongs to visual criteria, which are mainly based on morphological or subjective findings.

But there may be an overlapping of sexual features, ranges of variation based up on male and female bones. This may cause hurdles or even impossibility of accurate sex determination. Second category for sexing of the hip bones is formulated up on measurements or objective techniques.

These methods are simpler to teach and are more accurate than morphological assessments. Third category of methods used for sex determination of human skeletal bones is discriminant function analysis. The basic theory of discriminant function analysis was proposed by Fisher.

This method has the practical advantage of permitting sexual determination of poorly preserved remains over other methods **(8)**. The methods of sex determination of skeletons are not accurate and constant efforts are being made timely to improve them. Hence we conduct the present study for sex determination of human hip bones by discriminant function analysis.

MATERIALS & METHODS

The present study was been conducted in the department of Anatomy, S.P. Medical College, Bikaner and Other Medical Colleges of Rajasthan. 200 dry adult human hip bones presenting with no deformity or fracture were selected for the study. This was based on side determination and observations of hip bones and total of nine morphological characteristics of each bone which thereafter classified 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 medial aspect of ischiopubic ramus. Twelve features on the hip bone measured for the Objective sexing. The measurements of parameters were measure to the nearest tenth of a millimetre using verniercalipers, osctometric board and a metallic scale.

The pubic angle was measure by using a goniometer. Total pelvic height and Acetabular height (diameter) were measured and defined. Our study index wasdefine as = Total pelvic height / acetabular height (diameter) and used for sex determination and discriminant function analysis. The measurements were subject to statistical analysis i.e.

Univariate, bivariate, and multivariate analysis using were analysed using MS Excel 2010, Epi Info v7 and SPSS v22.

RESULTS

The present study included 200 intact human hip bones. After side determination of each hip bone they were classified into five different categories according to their nine morphological features.
Table 1 represents the grouping of hip bones into five divisions (Definite male, Probable male, Don't Know, Probable Female and Definite Female) by the application of the visual criteria.

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

		Total pelvic height	Acetabular height	Index
Definite Male	Mean	20.70	5.06	4.10
	S.D	1.09	0.27	0.14
.	S.E	0.15	0.04	0.02
	Range	18.7-22.8	4.61-5.57	3.86-4.58
Definite Female	Mean	18.36	4.32	4.25
	S.D	0.92	0.22	0.14
	S.E	0.29	0.07	0.05
	Range	16.8-19.4	3.82-4.62	3.98-4.41
P- value		0.195	0.067	0.188

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

	Total pelvic height		Acetabular height		Index	
	mean difference	p-value	mean difference	p-value	mean difference	p-value
DEFINITIVE MALE V/S DEFINITIVE FEMALE	2.3360	**0.0417**	0.7358	**0.0001**	-0.1563	**0.0052**
DEFINITIVE MALE V/S PROBABLE FEMALE	0.8810	0.1320	0.1938	0.0852	0.0115	0.0912
DEFINITIVE MALE V/S PROBABLE MALE	0.0603	7.6390	-0.0436	9.0258	0.0423	0.0592
PROBABLE MALE V/S DEFINITIVE FEMALE	2.2757	0.0687	0.7794	**0.0012**	-0.1986	**0.0010**
PROBABLE MALE V/S PROBABLE FEMALE	0.8207	0.2430	0.2374	0.0521	-0.0309	0.0721
PROBABLE FEMALE V/S DEFINITIVE FEMALE	1.4550	0.0523	0.5420	**0.0072**	-0.1677	**0.0057**

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 total Pelvic height, acetabular height and study index were non-significant for sex of hip bone. Mean value of Total pelvic height and Acetabular height was higher in males. Mean values of our study index was higher in females than in males. Table 3 shows the P value for the study variables with statistically significant differences of means relating to their sex after applying Fisher test and LSD test using spss and epi info software. Mean differences of acetabular height was highly significant between definite male and definite female with P-value is <0.001.

Total pelvic height and our study index were also shows significant difference P -values of 0.0417 and 0.005 respectively. Between definite male and probable female, mean differences of total Pelvic height, acetabular height and study index were non-significant. Total Pelvic height, acetabular height and study index were also showed non-significant difference between definite male and probable male also same results with definite male and don't know. Between probable male and definite female, Acetabular height (P=<0.0012) and our study index (P- 0.001) were highly significant.

Between definite female and don't know, mean differences of acetabular height (P=< 0.0030) and our study index (P=0.0057) were highly significant. By applying bivariate statistic, using Karl Pearson correlation coefficients and the P values of measurements of study parameters it was find that total pelvic height showed very highly significant correlation with acetabular height. Acetabular height showed high significant negative correlation with our study index.

By applying multivariate statistics, using ANOVA test performed on each study variable and the p-value of significance has been derive for all the variables. Total pelvic height showed high significance but our study index found to be non-significant for sexing.

DISCUSSION

The present study included 200 human hip bones, out of which 170 were of unknown sex.

The bones were grouped into 5 different categories on the base of nine morphological criteria's. It had been observed in previous studies in the recent years that these nine visual criteria's were very useful in sexing of hip bones and therefore the same were considered for the present study.

A study conducted by Phenice 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 **(9).** This method was used byLovell with an accuracy of 83% **(10)**. The visual criteria were used in the study were comparable to previously used by above mention authors whose studies were based on bones of unknown sex. These authors classified the bones into mainly three categories i.e. male and female and those which were not these two categories were put in an indeterminate groups**(11)**. Whereas in the present study, the male and the female categories were further divide into, a definite and a probable group which tends to increase the reliability of present study. We considered two parameters and one index and subjected them to uni-, bi- and multivariate analysis.

After getting the most discriminant factor, 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 12 definite female and 38 definite males' bones. The results of this study showed that the means of the total pelvic height and pelvic width showed highly significant difference between male and female bones which are similar to the findings of Davivongs in Australian aborigine palves.

Davivongs's results showed that the significance of the sex differences for these parameters were high but the male and female ranges overlapped so widely that these had very low value for sex determination **(12)**. We found similar results in our study. These two parameters showed wide overlapping and value of these parameters is higher in male.

It was observed in our study that the mean values of acetabular height in males was much greater than in females and the sex differences of the means were very highly significant. This was similar to the findings of Schulter-Ellis **(13)**. The results of bivariate analysis showed the correlations between all the variables with each other irrespective of the category.

It was found that total pelvic height showed positive correlation with acetabular height as they were size related measure, which was also stated by Milne **(14)**. Positive correlation was also observed between total pelvic height and ischial length and this may be because of both being measures of height. Acetabular height showed positive correlation with total pelvic height.

Patriquinet al39 commented that a part of acetabular height was included in the measurement of ischial length, thereby justifying the positive correlation between the two. Acetabular height showed negative correlation with our study index because this parameter was use in their denominator while calculating the indices. Our study index (total pelvic height / acetabular height) showed weak positive correlation with total pelvic height.

We found our study index (total pelvic height/acetabular height) to be non-significant for sexing, similar to the findings of Milne **(14)**. The findings of Holland et al were in contrast to ours. It indicated that the female hip bones were different from males in those traits which were associated with a relatively larger pelvic inlet (a greater degree of curvature of the iliopectineal line and more posterior position of the auricular surface) **(15)**.

Milne, postulated total pelvic height to be a good indicator of sex which was similar to our study **(14)**. The single best variable found by discriminant function analysis in our study was acetabular height. But still there was

considerable overlapping in the range. The Acetabular height was significant measurement. It was higher in males because it is a height related measurement and in general, height of males is more.

CONCLUSION

We concluded from the present study that the single best variable found by discriminant function analysis in our study is Acetabularheight.Butstillthere was considerable overlapping in the range. Along with it total pelvic height was also good discriminators of sex. We found our study index (total pelvic height/acetabular height) to be non-significant for sexing. Therefore, it should not be use for sexual differentiation.

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