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Research Article

SEX DETERMINATION FROM ADULT HUMAN HIP BONE BY DIRECT DISCRIMINANT FUNCTION ANALYSIS

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A R T I C L E I N F O

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A B S T R A C T

Background: Determination of biological sex is one of the most important determinations to be made from human remains and is an essential first step in the development of the biological profile in forensics, anthropology and bioarchaeology. The aim of this study was to determine whether sexing of unknown adult human Hip bones can be done by applying values of morphometric parameters and formulae generated by present study on adult human Hip bones of known sex and to find out the best parameters for sex determination.

Methods: Various metric measurements were recorded using osteo metric board, measuring tape, non elastic thread, sliding calipers and vernier calipers on adult human Hip bones.

Results: Sex was correctly estimated by using direct discriminant function analysis, for the Hip bone 92.5 % of males and 84.2% of females, with a total accuracy of 89.4 %.

Conclusions: Present study exhibited better classification accuracy for multiple variables than those of single variables. In the Hip bone, the most discriminating variables in direct analysis is length of the hip bone.

INTRODUCTION

Sex determination of the human skeleton has been studied in forensic and physical anthropology. Sexual dimorphism in the context of physical anthropology refers to the skeletal differences which can be recognized between adult males and females based on visual and metric criteria. The dimensions of female skeletal parts as a percentage of male parts range from 90 to 96 per cent.[1]

Sexual dimorphism is evident in human foetuses particularly in the pelvis with the sciatic notch being wider in female foetuses and deeper in males and the subpubic angle larger in females.[2] Research shows that there exists a greater difference between the sexes of the foetal subpubic angle than in adults.

This is because in male infants the secretion of androgens beginning in prenatal life produces sexual dimorphism with a larger muscle mass, a higher birth weight and skeletal changes which are apparent in pelvic morphology.[3]

While DNA analysis has proven successful in identifying unknown victims and perpetrators of crime, it is of little value when there are no family members to positively identify or claim the deceased. [4,5,6]

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DNA and ante mortem dental records, are of little or no value. In these situations, Forensic personnel frequently consult the Anatomists to give their expert opinion for medico legal purposes, regarding the personal identity with respect to sex, age, stature, race and also probable cause of death. Examination of such skeletal remains forms the basis of their opinion.[7,8]

In the present scenario, forensic anthropologists are involved in discovering new methods of identification from skeletal remains, cadavers as well as living beings. The reason to work on new populations is that the earlier acquired standards of age and sex determination have lost their values due to secular changes in the modern populations.[9,10] Therefore, there is always a need to apply and test the methods to newer populations for making population standards for achieving precision and accuracy.

Therefore, it was suggested that osteometric studies should be considered “population specific”, which implies that sexual dimorphism varies between populations to such an extent that osteometric standards developed from one group cannot be reliably used on another population .[11]

Very few studies are available in India on determination of sex from human skeleton, so present study made a sincere effort to enhance the accuracy of sex determination from using various parameters of Hip bones by applying direct

Discriminant function analysis on population of Marathwada region of Maharashtra.

METHODS

The bones used in this study were obtained from Govt. Medical College, Aurangabad, Maharashtra. For the study, fully ossified dry bones, free of damage or deformity were used. Total of 320 bones were selected for the study out of which 200 were of males and 120 were of females. All the measurements were measured in millimeters.

Present study was done on dry human bones, so ethical issues were not arised.

HIP Bone Measurements

1. Length (L): distance from the most superior point on the iliac crest to the most inferior point on the ischial tuberosity is measured with osteometric board.
2. Width (WD): distance from anterior superior iliac spine to posterior superior iliac spine is measured with osteometric board.
3. Distance between anterior superior iliac spine and pubic tubercle (ASIS-PT): distance between anterior superior iliac spine and pubic tubercle is measured with vernier calipers.
4. Distance between anterior superior iliac spine and ilio pubic eminence (ASIS-IPE): distance between anterior superior iliac spine and ilio pubic eminence is measured with vernier calipers.
5. Distance between posterior superior iliac spine and posterior inferior iliac spine (PSIS-PIIS): distance between posterior superior iliac spine and posterior inferior iliac spine is measured with vernier calipers.
6. Distance between posterior superior iliac spine and ischial spine (PSIS-IS) : distance between posterior superior iliac spine and ischial spine is measured with vernier calipers

RESULTS

An analysis of variance test (ANOVA) provided descriptive statistics including the means, standard deviations and F-ratios of all the variables in both sex groups (Table 1).

Table 1 Means, Standard deviations, Univariate F-ratio and demarking points for the Hip bone

Variable Descriptions	Males (n =200)			Females (n = 120)					
	Mean	SD	SE	Mean	SD	SE	F- ratio	t -test	p value
HIP BONE									
L	197.53	7.42	0.52	177.50	8.63	0.78	482.24	21.96	.000
WD	141.38	7.85	0.55	132.39	5.95	0.54	116.86	10.81	.000
ASIS-PT	109.54	5.19	0.36	103.16	5.50	0.50	108.12	10.39	.000
ASIS-IPE	70.71	5.15	0.36	65.87	3.79	0.34	79.66	8.92	.000
PSIS-PIIS	35.68	4.55	0.32	31.45	2.96	0.27	82.20	9.06	.000
PSIS-IS	77.11	6.27	0.44	76.27	5.13	0.46	1.53	1.23	.217

The greatest differences in mean values appeared to be in Length (males: 197.53 mm, females: 177.50 mm.) statistically significant difference ($p < 0.001$) was found between males and females for the osteometric variables of Hip bone for all variables except distance between posterior superior iliac spine and ischial spine ($p = 0.217$).

Direct discriminant analysis of Hip bone (Function 1 to 5, Tables 2,3 & 4) (each variable separately)

A direct analysis was carried out on all individual variables of hip bone separately to identify the most constructive variable in statistically discriminating between the sexes. The results of the direct analyses and discriminant function score formula for each variable appear in Tables 2, 3 and 4 as Function 1 to 5.

Table 2 Variable wise calculation of discriminant functions of Hip bone (Direct analysis)

Function	Variable	unstandardized co efficient	standard coefficient	structured coefficient	Wilks Lambda	F ratio	eigen value	canonical correlation
1	L	0.127	1	1	0.397	482.24	1.516	0.776
2	WD	0.139	1	1	0.731	116.86	0.368	0.518
3	ASIS-PT	0.188	1	1	0.746	108.12	0.340	0.504
4	ASIS-IPE	0.213	1	1	0.800	79.66	0.251	0.448
5	PSIS-PIIS	0.248	1	1	0.795	82.20	0.259	0.453
	L	0.148	1.166	0.967				
6	WD	-0.035	-0.254	0.476				
All	ASIS-PT	-0.035	-0.184	0.458	0.381	-	1.622	0.787
Variables	ASIS-IPE	0.000	-0.002	0.393				
	PSIS-PIIS	0.049	0.196	0.399				

By direct analysis, length is the best discriminant variable among all variables with 91 % for males and 80.8 % for females and 87.2 overall accuracy.

Direct discriminant analysis (Function 6, Tables 2, 3 & 4) (all variables entered together)

A direct discriminant analysis was applied to evaluate the diagnostic ability of all variables entered together in direct discriminant analysis (Function 6, Tables 2, 3 and 4)

D= Discriminant function score.

Discriminant function score formula for Function 6 analysis of Hip bone is

D = -21.105 + 0.148* L -0.035* WD -0.035* ASIS-PT + 0.000* ASIS-IPE +0.049* PSIS-PIIS

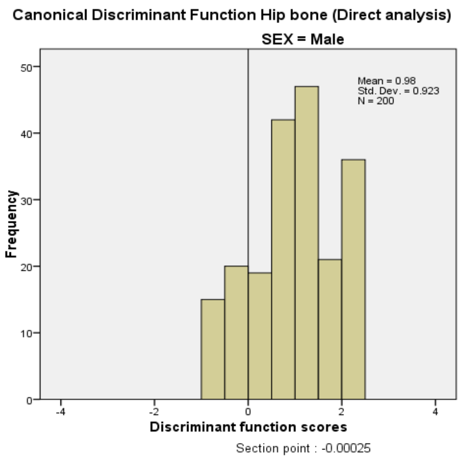
The classification accuracy of the hip bone for the discriminant function formulae are presented in Table 4.

For the hip bone, Function 6 analysis showed that 185 males out of 200 cases were correctly classified with 15 individuals misclassified as females, thus resulting in 92.5 % accuracy.

101 females out of 120 cases were correctly classified with 19 individuals misclassified as males, thus resulting in 84.2 % accuracy.

Total 286 out of 320 cases were correctly classified with total accuracy of 89.4 %.

Cross validation showed similar results of original analysis.



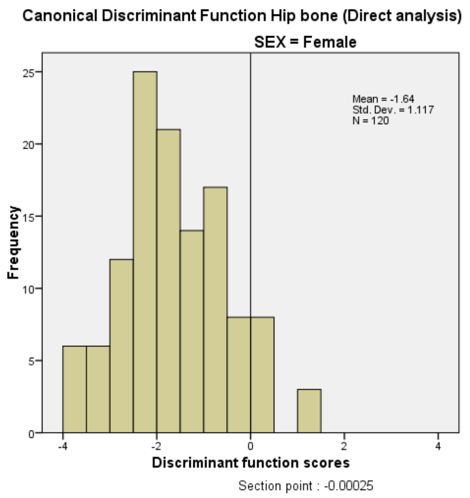
pelvic height, sciatic notch height and the acetabular height were the most useful indicators in sexing of hip bones.[14]

Table 3 Discriminant function equation for determining sex of Hip bone (Direct analysis)

Function	Variable	Constant	Discriminant equation	Group centroid		Sectioning point
				Male	Female	
1	L	-24.056	B = -24.056 + 0.127*L	0.951	-1.585	0
2	WD	-19.156	B = -19.156 + 0.139*WD	0.468	-0.780	0
3	ASIS-PT	-20.171	B = -20.171 + 0.188*ASIS-PT	0.450	-0.750	0
4	ASIS-IPE	-14.686	B = -14.686 + 0.213* ASIS-IPE	0.386	-0.644	-0.00025
5	PSIS-PIIS	-8.447	B = -8.447 + 0.248* PSIS-PIIS	0.393	-0.654	0.000375
6	All variables	-21.105	B = -21.105 + 0.148* L -0.035* WD - 0.035* ASIS-PT + 0.000* ASIS-IPE +0.049* PSIS-PIIS	0.983	-1.639	-0.00025

Table 4 Percentage of predicted group membership and cross validation for the Hip bone (univariate)

Function	Variable	% of bones Correctly classified					
		Male (n =200)		Female (n =120)		Total (n=320)	
		original	Cross validated	original	Cross validated	original	Cross validated
1	L	182	182	97	97	279	279
		91	91	80.8	80.8	87.2	87.2
2	WD	165	165	66	66	231	231
		82.5	82.5	55	55	72.2	72.2
3	ASIS-PT	160	160	63	63	223	223
		80	80	52.5	52.5	69.7	69.7
4	ASIS-IPE	171	171	59	59	230	230
		85.5	85.5	49.2	49.2	71.9	71.9
5	PSIS-PIIS	159	159	62	62	221	221
		79.5	79.5	51.7	51.7	69.1	69.1
6	All variables	185	185	101	101	286	286
		92.5	92.5	84.2	84.2	89.4	89.4



Graph1 Discriminant scores of Hip bone by sex using multivariate equation

D= -21.105 + 0.148* L -0.035* WD -0.035* ASIS-PT + 0.000* ASIS-IPE +0.049* PSIS-PIIS

DISCUSSION

Sex determination using human skeletal remains is one of the most important components in forensic identification and starting point of anthropologic researches. Sex determination is the most significant information which can be obtained from bones.

Takahashi H. found that the posterior angle is the best discriminating variable with an accuracy of 91% and sex was determined correctly in 88% of cases.[12] Singh S *et al* found that the length of posterior segment and posterior angle of greater sciatic notch were very useful in sex determination. The sex was identified correctly in 88-92%.[13] Rajangam S *et al*, studied hip bones of unknown sex of Karnataka origin. 87.7% of hip bones could be accurately classified. The total pelvic height, sciatic notch height and the acetabular height were the most useful indicators in sexing of hip bones.[14]

Akpan T.B *et al* studied using greater sciatic notch to determine the sex in hip bones. Posterior angle was found to be most useful in assigning sex with an accuracy of 75-90%.[15] The accuracy of a method for visually scoring sex differences in the greater sciatic notch was tested by Jaroslav Bruzek. The proportion of correct sex assignment is 80% when all the specimens are classified and 89% when os coxae assigned the scope in which sexes show greatest overlap are excluded.[16]

Present study shows, the most discriminating variables included in the analysis is Length of hip bone with 91% accuracy in males and 80.8% accuracy in females, Width of hip bone with 82.5% accuracy in males and 55% accuracy in females. Distance between anterior superior iliac spine and pubic tubercle with 80% accuracy in males and 52.5% accuracy in females, Distance between anterior superior iliac spine and ilio pubic eminence with 85.5% accuracy in males and 49.2% accuracy in females, Distance between posterior superior iliac spine and posterior inferior iliac spine with 79.5% accuracy in males and 51.7% accuracy in females, Distance between posterior superior iliac spine and ischial spine with 79.5% accuracy in males and 51.7% accuracy in females. The most discriminating variables included the length of the hip bone with overall accuracy 87.2%.

CONCLUSION

In general, the analyses with multiple variables exhibited better classification accuracy than those of single variables. This was to be expected as it has been repeatedly demonstrated that using a combination of various measurements leads to a higher rate of accuracy than when only a single variable is employed. In much the same way, using several skeletal elements yields higher rates of accuracy than using a single bone.

Present study also exhibited better classification accuracy for multiple variables than those of single variables.

In summary, the measurements of the hip bone appear to be moderate discriminators of sex in present sample analyzed by direct discriminant function analysis. In the direct discriminant function analysis, the most discriminating variables included the length of the hip bone.

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References

1. Krogman, Wilton Marion and Iscan Mehmet Yasar. The Human Skeleton in Forensic Medicine. second ed. Springfield: Charles C Thomas 1986 :(p.190)
2. Boucher, B.J. Sex Differences in the Foetal Pelvis. *American Journal of Physical Anthropology.* 1957: (p.597).
3. Saunders, S.R. Juvenile Skeletons and Growth related Studies. In Biological Anthropology of the Human Skeleton, edited by M. A. a. S. Katzenberg, S.R. Hoboken: A John Wiley and Sons 2008 (pp. 122-123).
4. Goes AC, Silva DA, Domingues CS, Sobrinho JM, Carvalho EF. Identification of a criminal by DNA typing in a rape case in Rio de Janeiro, Brazil. Sao *Paulo Med J.* 2002; 120(3):77-79.
5. Iscan MY, Solla H.E., McCabe B.Q. Victim ofa dictatorial regime: identification of Mr. Roberto Gomensoro Josman. *Forensic Sci Int*. 2005; 151(2-3):213-220.
6. Oz C, Levi JA, Novoselski Y, Volkov N, Motro U. Forensic identification of a rapist using unusual evidence. *J Forensic Sci*. 1999; 44(4):860-862.
7. Krishan K. Anthropometry in Forensic Medicine and Forensic Science: Forensic Anthropometry*; Internet J Forensic Science.* 2007, Vol. 2(1).
8. Padeyappanavar KV., Kazi AM., Bhusareddy PS., Kulkarni UK. Sexual dimorphism in adult human clavicles of North interior Karnataka. *J Karnataka Medico-legal Soc*, 2009 June; 18(1):3-13.
9. Ulijaszek SJ, Masci-Taylor CJN. Anthropometry: The individual and the population, Cambridge studies in biological anthropology. Cambridge UK: Cambridge University Press, 1994: (213)
10. Eveleth, P B and Tanner, J M. World-wide Variation in Human Growth, Cambridge: Cambridge University Press, 1976: (287)
11. Novotny V, İşcan MY, Loth SR. Morphological and osteometric assessment of age, sex and race from the skull. In: İşcan MY, Helmer RP, editors. Forensic Analysis of the Skull. Wiley-Liss, Inc; 1993.p. 71-88.
12. Takahashi H: Curvature of greater sciatic notch in sexing the human pelvis. *Anthropological science* 2006; vol 114:187-91 .
13. Singh S, Potturi BR. Greater sciatic notch in sex determination. J Anat. 1978 Mar; 125 (Pt 3):619-24.
14. Rajangam S, Janakiram S, Thomas I M. Sexing of hip bones of karnataka origin. *Journal of anatomy soc India* 1991; vo l40: 105-08.
15. Akpan T B, Igiri A O, Singh S P: Greater sciatic notch in sex differentiation in Nigerian skeletal samples. *Afr. J. med. Sci*. 1998; 27(1-2): 43-46.
16. Jaroslav Bruzek: A method for visual determination of sex using human hip bone; *American journal of physical anthropology* 117:157- 168(2002).

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