ORIGINAL ARTICLE

Osteoscopic Assessment of Sexual Dimorphism in Hip Bone

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Introduction: The pelvis is most sexually dimorphic and is the first bone assessed in sex determination because it is the skeletal element most affected by reproduction and parturition.[1] The assessment of the pelvis is made through metric measurements as well as through the visual analysis of non-metric traits; both important aspects of the analysis. The best methods for determining sex from adult skeletal remains involve measurement and inspection of the hip bone that presents a number of gender-related anatomical differences.[2] Most osteologists visually (stereoscopic) evaluate these differences and integrate this subjective assessment ofhip bonemorphology into their sex determinations. The aim of thepresent study is to visually evaluate sexual differences in hip bone and comparing its efficacy with metric assessment. **Methods:** This study is done on 46 hip bones of adult individuals of known sex from museum of department of anatomy of SGRRIM&HS Dehradun and TMMC&RC Moradabad, India. All these hip bones were visually examined and under mentioned five characters of the hip bone were used, (A) aspects of the preauricular surface, (B) aspects of the greater sciatic notch, (C) the form of the composite arch, (D) the morphology of the inferior pelvis, and (E) ischiopubic proportions. **Results:** In this study traits of the group (A) were most sexually dimorphic while traits of the group (E) were least sexually dimorphic. **Conclusion:** Diagnostic accuracy is excellent when the complete hip bone is available. Hip bone features used for sex determination by visual assessment seem to be fairly stable.

Keywords: Hip bone, Metric and nonmetric traits

INTRODUCTION

The accurate estimation of the sex of a skeletonized human is important to anthropologists, bio archaeologists, and anatomists.[3] The bones of the pelvis, especially those of the anterior part, are the most significant predictors of the sex.[3-8] The assessment of the pelvis is made through metric measurements as well as through the visual analysis of non-metric traits; both important aspects of the analysis. Pubic bones are fragile, however, and often damaged, especially in archeological collections.[9] In these instances, other portions of the pelvis that are more resistant to damage can be used to determine the sex of an individual, such as the greater sciatic notch and auricular surface of the ilium.[10] The best methods for determining sex from adult skeletal remains involve measurement and inspection of the hip bone that presents a number of gender-related anatomical differences.[2] Numerous techniques of sex estimation have been proposed, based either on osteoscopic assessment or recording of lineal metric variables of the hip bone.[11-16]

If the pelvis is unavailable, anthropologists look to the skull, the femoral and tibial shafts,[17] and dentition[18,19] for sex determination. Most osteologists visually evaluate these differences and integrate this subjective assessment morphology into their sex determinations.

Metric characters can be problematic because robust females and smaller man pose difficulties in interpretation, this is the reason nonmetric characters are more reliable for assessment of the biological profile. Methods may vary greatly and can significantly alter the outcome of sex determination,anthropologists often disagree on sexing methodology. Nonetheless, previous research on this topic indicates that the accuracy of sex estimation is an important goal in anthropology. Since its publication, (Sutherland & Suchey, 1991)[20] has become the most well-known and most widely used method for visual determination of sex. It has been tested various times.[21-23] Metric and nonmetric bone traits are polygenetic, and bone morphology is an attribute of gene expression, which shapes the nonmetric traits seen in the pelvis.[24]

METHOD

This study is done on 46 hip bones of adult individuals of known sex from museum of department of Anatomy of SGRRIM&HS Dehradun and TMMC&RC Moradabad, India. All these hip bones visually examined. Five characters of the hip bone were used. Aspects of the

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preauricular surface, (B) Aspects of the greater sciatic notch, (C) The form of the composite arch, (D) The morphology of the inferior pelvis, and (E) Ischiopubic proportions (Figure 1 and Table 1).

S1: Paraglenoid groovef – deep depression well-delimited (pits), i – intermediate form, m – relief smooth or very slightly negative relief.

S2: Aspect of grooves or pitting, f – pits or groove with closed circumference, i – intermediate form, m – depression with open circumference.

S3: Development of positive relief on preauricular surface, f – lack of tubercle, i – intermediate form, m – tubercle present or clear protuberance.

S4: Proportion of length of sciatic notch chords, f – posterior chord segment longer than or equal to anterior chord, i – intermediate form, m – posterior chord shorter than anterior chord.

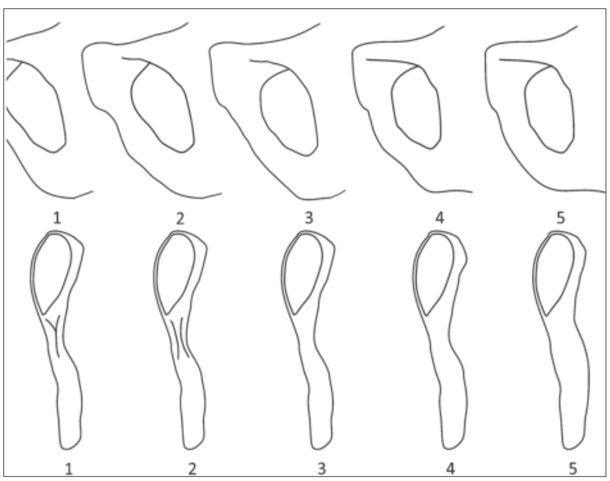

Figure 1: Upper line showing different types of Subpubic contour and lower line showing different type of Ischio-pubic ramus

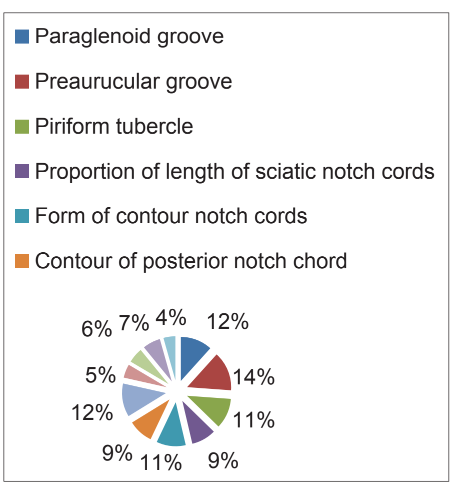

Figure 2: Percentage of each character used in the study

S5: Form of contour notch chords, f – symmetry relative to depth in basal portion of sciatic notch, i – intermediate form, m – asymmetry relative to depth of sciatic notch.

S6: Contour of posterior notch chord, f – outline (contour) of posterior chord does not cross perpendicular line, i – intermediate form, m – contour of posterior chord crosses perpendicular line

S7: Relation between outline of auricular surface, and outline of sciatic notch, f – double curve, i – intermediate form, m – single curve.

S8: Characterization of margo inferior ossis coxae, f – external eversion, i – intermediate form, m – direct course of medial part.

S9: Phallic ridge, present or absent,

f – lack of the phallic ridge or presence of only little mound, i – intermediate form, m – clear presence of the phallic ridge.

Table 1: Character of hip bone used in the study

Groups	Traits	Symbol
A (Preauricular surface)	Paraglenoid groove	S1
	Preauricular groove	S2
	Piriform tubercle	S3
B (Greater sciatic notch)	Proportion of length of sciatic notch cords	S4
	Form of contour notch cords	S5
	Contour of posterior notch chord	S6
C (Composite arch)	Composite arch	S7
D (Inferior pelvis)	Margo inferior ossis coxae	S8
	Phallic ridge	S9
	Ischio-pubic ramus aspect	S10
E (Ischiopubic proportion)	Ischiopubic proportion	S11

Table 2: Percentage of each character used in the study

Groups	Traits	Symbol	Present study (%)
A (Preauricular surface)	Paraglenoid groove	S1	76.2
	Preaurucular groove	S2	94.2
	Piriform tubercle	S3	72.8
B (Greater sciatic notch)	Proportion of length of sciatic notch cords	S4	58.9
	Form of contour notch cords	S5	70.1
	Contour of posterior notch chord	S6	59.6
C (Composite arch)	Composite arch	S7	80
D (Inferior pelvis)	Margo inferior ossis coxae	S8	32.6
	Phallic ridge	S9	36.4
	Ischio-pubic ramus aspect	S10	42.6
E (Ischiopubic proportion)	Ischiopubic proportion	S11	28.6

S10: Ischio-pubic ramus aspect, f – gracile aspect, i – intermediate form, m – robust aspect.

S11: Relation between length of pubis and ischium, f – pubis longer than ischium, i – intermediate form, m – ischium longer than pubis.

RESULTS

The non-metric trait S2 is present in most of the hip bones while S11 trait is present in least hip bones under study. Decreasing order of different non-metric traits under study is as under.

S11 < S8 <S9 <S10 <S4 <S6 <S5 <S3 <S1 <S7 <S2.

Results obtained in this study show that nonmetric traits of Preauricular surface are present in most of the hip bones and non-metric trait of ischiopubic proportion are present in least number of hip bones under study (Table 2 and Figure 2).

DISCUSSION

The nonmetric traits which are used in this study reflect the morphology of two very distinct areas of the pelvis: The sacroiliac complex and the ischiopubic complex. The first three characters are sex-specific adaptations of the sacroiliac complex to bipedal locomotion. The fourth and fifth characters (the ischiopubic complex) reflect the adaptation of the female pelvic canal to the requirements of reproduction. Combination of all nonmetric traits makes the result very homogenous.

With respect to the accuracy of sex determination in men and women, (Novotny et al,1981)[25] considered that the female skeleton is seldom incorrectly diagnosed. This is apparently due to less variability in female pelvic size.

Reduced variability in pelvic size of women has not, however, been statistically demonstrated.[26,27] Greater pelvis is more variable in men than in women. Inversely, the lesser pelvis is more variable in women.

The total degree of sexual dimorphism of the hip bone is a function of the interaction of the partial dimorphism of the two main regions of the pelvis. Thus, according to the concept of functional integration, lower levels of sexual dimorphism in one morpho-functional pelvic complex (i.e., openness vs. closure of the greater sciatic notch) can be functionally compensated by higher levels of dimorphism in the other morpho-functional pelvic complex (i.e., ischiopubic proportions).

The binary scoring method of (Osborne, Simmons, Nawrock, 1984)[28] for sex evaluation compares favorably with other methods that use criteria such as "smaller than" or "larger than." Binary scoring rather than subjective assignment allows for the systematic accommodation of more of the inherent variation seen in pelvic morphology.

According to (Byers, 2002),[4] diagnostic accuracy of sex determination is excellent when the complete hip bone is available.

Ischiopubic proportion (S11) was present in least persons and Preauricular groove (S2) was present in most of the hip bones under study, which shows concordance with Bruzek study. All other features of hip bones found to be almost similar to the study of Bruzek, but accuracy in Bruzek study is more as compared to the present study, which explains inter-observer differences between the previous and the recent study.

(Iscan & Derrick,1984)[29] achieved only 79–81% accuracy based on the shape of the sciatic notch. This is because gender based characteristics of the sciatic notch are difficult to assess by visual examination.

As noted by (Bruzek, 2002)[3] not only is the observerinfluenced by the size of the pelvis, but by the development of marginal structures. Therefore, this analysis would be very subjective.

Although geographic differences with the reference sample in the expression of sex-related anatomical features cannot be ruled out, the use of Bruzek method in our sample seems valid since hip bone features used for sex determination seem to be fairly stable.

This study demonstrated that sex could be satisfactorily determined even on a fragment of hip bone.

The posterior region of the hip bone including the sciatic notch is particularly informative, since the Sacro-iliac joint can also be used to evaluate another essential parameter, i.e. the age at death.[30]

Os coxae with sciatic notches well enough preserved to be measurable are thus likely to have intact pubic bones. In such cases, the presence of more reliable pubic sex indicators makes resorting to the sciatic notch unnecessary. Reliance on the visual assessment of sciatic notch morphology has the disadvantage of introducing a subjective element into sex determinations.

Numerous sex determination techniques have been proposed based either on examination of specific parts of the hip bone including the pubic bone,[20,21] sacro-iliac joint,[10] or on examination of the whole hip bone.[4,2,11]

In young individuals sex determination is very difficult and unreliable because skeletal differences are not very marked till puberty. However, in order to utilize this size difference in sex determination, the researcher must be able to identify the population from which a skeleton came, as populations differ greatly in average skeletal size and degree of sexual dimorphism and proportions. Populations native to India usually have smaller skeletons and exhibit less sexual dimorphism than Australian Aborigines. An adult male Asian Indian skeleton placed alongside a male (or many females) adult Australian Aborigine skeleton would, if judged on the basis of size, be misclassified as a female. This indicates that the size differences between these two populations could easily confuse sex differences. For this reason, morphological differences are usually more reliable than are general size differences, particularly if one is not sure from what population an individual is derived.

CONCLUSION

The only biological features that consistently represent the individual are osseous elements, but these elements may be fragmentary or poorly preserved in many settings. Methods that yield accurate sex estimates for individuals from skeletal samples are thus crucial for more complete characterizations and studies of past human populations. However, some problems could arise when two similar individuals deviating slightly from the sectioning point are classified on the opposite side even if they represent the same sex.[31]

REFERENCES

1. Byers, SM. *Introduction to Forensic Anthropology*: A Textbook, Second Edition. Boston,MA: Pearson Education, Inc. (2005).
2. Ferembach D., Schwidetzky I., Stloukal M.Recommendations for age and sex diagnoses of skeletons. *J of Hum. Evol*. 1980; 9*:* 517–549.
3. Bruzek J. A method for visual determination of sex, using the human hip bone. *Am J Phys Anthropol*. 2002; 117*:* 157-168.
4. Rogers T, Saunders S. Accuracy of sex determination using morphological traits of the human pelvis. *Journal of Forensic Sciences*. 1994; 39(4): 1047-1056.
5. Shwartz JH. Skeleton Keys: An introduction to human skeletal morphology, development, and analysis. New York: Oxford University Press 2007.
6. White TD.Human Osteology. San Diego: Elsevier Academic. (2000).
7. Walker PL. Greater sciatic notch morphology: Sex, age, and population differences. *American Journal of Physical Anthropology*. 2005; 127 *(*4): 385-391.
8. Ali RS, Maclaughlin S. Sex identification from the auricular surface of an adult human ilium. *International J. of Osteoarchaeology.* 1991; 1*:* 57–61.
9. Albanese J.A metric method for sex determination using the hip bone and the femur. *J. of Forensic Sciences:* 2003; 48 *(*2): 263–273.
10. Boucher BJ. Sex differences in the foetal pelvis. *Am. J. Phys. Anthropol*. 1957; 15*:* 581–600.
11. Bennardo R, Taylor JV. Multiple discriminant function analyses of sex and race in the postcranial skeleton. *Am J Phys Anthropol*. 1983; 61:305–314.
12. MacLaughlin SM and Bruce MF. The accuracy of sex identification in European skeletal remains using the Phenice characters. *J Forensic Sci*. 1990; 35*:* 1384-1392.
13. Phenice TW. A newly developed visual method of sexing the os pubis. *Amer. J. of Phys. Anthrop*.1969; 30*(*2): 297–301.
14. Risse*ch* A, Malgosa A.Sex prediction by discriminant function with central portion measures of innominate bones. *Homo*. 1997; 48*:* 22–32.
15. Lorenzo P., Bayliss, MT, and Heinegar, D. A novel cartilage protein (CILP) present in the mid-zone of human articular cartilage increases with age. *J. Biol. Chem*. 1998; 273*:* 23463-23468.
16. Castro B, Rozzi R, Martinontorres M., Perez S., Rosas A. Patterns of dental development in Lower and Middle Pleistocene hominins from Atapuerca (Spain), in J.L. Thompson, G.E.
17. Krovitz, A.J. Nelson (ed), Patterns of Growth and Development in the genus Homo, CambridgeUniversity Press, Cambridge, p. 246-270.
18. Frayer DW and Wolpoff, HM. Sexual dimorphism. *Ann. Rev. Anthropol*. 1985; 14:429-73.
19. Kelley MA. Sex determination with fragmented skeletal remains. *J Forensic Sci.* 1979; 24:154–158.
20. Lovell NC. Test of Phenice's method for determining sex from the os pubis. *Am J Phys Anthropol*. 1989; 79:117–120.
21. Sutherland LD, Suchey JM. Use of the ventral arch in pubic sex determination. *J Forensic Sci* 1991; 36*:* 501–511.
22. Gosman JH, Stout SD, Larsen CS. Skeletal biology over the life span: A view from the surfaces. *Am J Phys Anthropol*. 2011; 146*:* 86–98.
23. Meindl RS, Lovejoy CO, Mensford RS, Don Carlos L. Accuracy and direction of error in the sexing of the skeleton: Implication for paleo demography. *Am J Phys Anthropol* 1985; 68:79–85.
24. Tague RG. Variation in pelvic size between males and females. Am J Phys Anthropol1989; 80*:* 59–71.
25. Pachner P. Pohlavnı´ rozdı´ly na lidske´ pa´nvi [Sex differences of human pelvis]. *Prague: Cˇ eska´ Akademie Veˇd a*1937;. Umeˇnı´.
26. Novotny´ V. Pohlavnı´ rozdı´ly a identifikace pohlava´ pı´nevnı´ kosti [Sex differences and identification of sex in pelvic bone]. Ph.D. thesis, Purkyneˇ University, Brno. 1981.
27. Di Bennardo R, Taylor JV. Multiple discriminant function analyses of sex and race in the postcranial skeleton. *Am J Phys Anthropol.* 1983; 61:305–314.
28. Lovejoy CO, Meindl RS, Pryzbeck T R, Mensforth RP.Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of adult skeletal age at death. *Amer. J. of Phys. Anthrop*.1985; 68(1)*:* 15–28.
29. Osborne DL, Simmons TL, Nawrocki S P. Reconsidering the auricular surface as an indicator of age at death. *J. of Forensic Sciences*. 2004; 49*(*5)*:* 905–911.
30. Iscan MY, Derrick K. Determination of sex from the sacroiliac: A visual assessment technique. *Florida Sciences*.1984; 47*:* 94–98.
31. Schulter Ellis FP, Hayek LA, Schmidt DJ, Craig J. Determination of sex with a discriminant analysis of new pelvic bone measurement. *I J For Sci*. 1983; 28: 169-180.

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