Original Article

ROLE OF ISCHIO-PUBIC INDEX IN SEX IDENTIFICATION FROM INNOMINATE BONES IN NORTH INDIAN POPULATION

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ABSTRACT

Background: The use of coxal elements for age & sex identification is primary and most widespread way of bringing us closer to the identity of dead individuals in archaeological & certain forensic scenarios. It is well known that there is metric & morphologic variation in expression of sexual dimorphism between racial phenotypes and populations. Therefore, the purpose of present research is to assess metric differences in the pubo-ischial region of hip bones amongst North Indian Population.
Material & Methods: Material for the current investigation comprised of 100 hip bones [(M: F=80:20) & (R: L=50:50)] obtained from Department of Anatomy, Government Medical College, Amritsar, Punjab, India. Pubic Length & ischial length were measured and Pubo-ischial index was calculated. All the data thus obtained was compiled, tabulated and statistically analyzed.
Results: All the three parameters showed statistically significant sex differences. Ischium was longer in males, pubis in females & pubo-ischial index was also more in females.
Conclusion: These variables can be used to determine sex from human hip bone or its fragments.
KEYWORDS : Pubic Length, Ischium Length, Pubo- ischial Index, Sex Determination, Racial Differences

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INTRODUCTION

Anatomists are frequently consulted for identification of skeletal remains found under suspicious circumstances. Traditional methods for the assessment of sex on the pattern of skeletal morphology do not have an explicit basis. Visual impressions of the bones can seldom be as accurate because of the many pitfalls associated with subjective assessments of the observer. Forensic expert is often faced with a single specimen on whom he is asked to pronounce an opinion about its origin in general terms; or it may be necessary to establish as probably belonging to a given person when the identity is already suspected on circumstantial evidence [1].

Along with the common features of sex differences in the skeleton, additional sex differentiating features are considered in case of pelvic girdle because of its reproductive functions

mainly influenced by the sex hormones [2]. The distinctive morphology of hip bone and its clear sexual dimorphism make it of interest from anatomical, anthropological & forensic points of view [3].

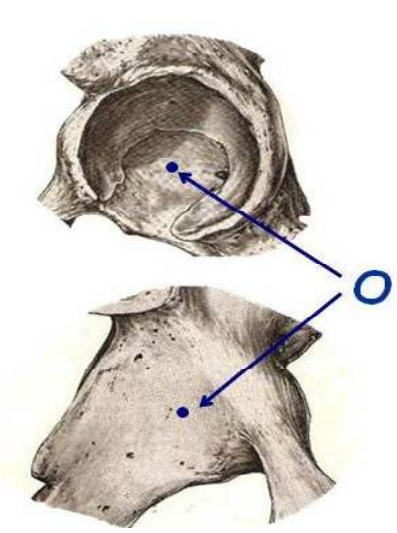
The pelvic bones are the most important for sex determination, followed by the skull and the long bones. Although the remaining skeletal parts can be used as well, they are less important but the accuracy of sex determination increases if the additional skeletal elements are utilized. In general, male bones are identifiable by their greater robusticity, but this is a question of relativity. The sex classification of a bone is possible with a degree of certainty only when it can be compared to a series of known sexual dimorphism [4].

Traditional methods involving many measurements, indices & observations are cumbersome & frequently unreliable. A simple method which will determine the sex of a majority of skeletons is based on the ischium- pubic index. The pubic bone of adult female is longer than that of the male. On the other hand, the male ischium is longer than that of female. The ischium-pubic index takes an advantage of these relations, and is an efficient indicator of sex.

MATERIALS AND METHODS

Material for the present study comprised of 100 hip bones of known sex (M: F = 80:20) and side (R: L= 50:50); obtained from Department of Anatomy, Govt. Medical College, Amritsar, Punjab, India. The bones were undamaged and showed no pathological changes.

Fig. 1: Locating acetabular point O.



Before taking any of these measurements central point of acetabulum (Fig I) was located. Schultz (1930) [5] described following methods:

a) Frequently there is an irregularity both in the acetabulum and inside the pelvis.

b) There is a change in thickness which may be seen by holding the bone upto the light.

c) Often there is a notch in the border of the articular surface in the acetabulum.[5]

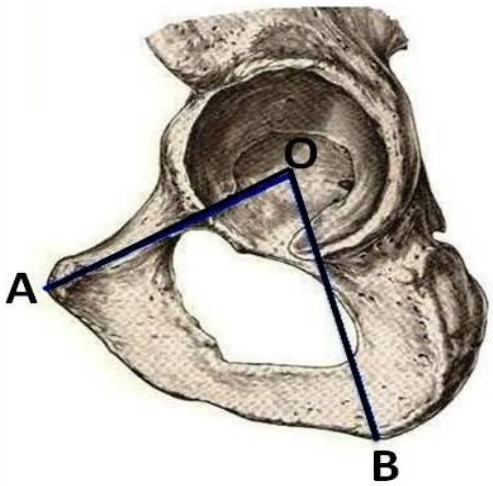
In the present study, method (a) of Schultz (1930) [5] was used as irregularity could be easily palpated.

After marking central point of acetabulum, following two variables were measured with vernier calipers & the index was calculated:

1. Pubic Length (Length of pubic bone) **-** It is the greatest distance of the central point of the acetabulum from the symphyseal surface of the body of pubis [6] (OA in Fig. 2).

2. Height of Ischium (Termed as Length of ischium by Davivongs, 1963 [2]) – Seidler (1980) [6] described it as the greatest distance between the central point of acetabulum and the farthest point on inferior aspect of ischial tuberosity which has been named ischial point by Thieme (1957) [7] (OB in Fig. 2). It was recorded with the help of vernier callipers on both the sides.

Fig. 2: Showing Pubic Length (OA), Ischial Length (OB).



3. Ischiopubic index: It was calculated as [2]

$$= \frac{\text{Pubic Length (Sr. No. 1)}}{\text{Ischial length (Sr. No. 2)}} \times 100$$

For all the three parameters, mean, range, standard deviation and 95% confidence intervals

of mean in both the sexes are depicted in Table I. To this independent Student's t-test for equality of means was applied and 't' and 'p-values' were calculated to find out the significant differences between the means for the two sexes.

RESULTS AND TABLES

Table 1: Results of the three Puboischial Parameters in Both Sexes with P- values.

Sex	Mean ± S.D.	Range	p-Value
PUBIC LENGTH			
Male	7.92 ± 0.71	5.63-9.34	<0.001*
Female	8.56 ± 0.47	7.75-9.53	
ISCHIAL LENGTH			
Male	8.07 ± 0.57	7.04-9.40	<0.001*
Female	7.31 ± 0.78	6.02-8.77	
PUBOISCHIAL INDEX			
Male	98.27 ± 7.33	70.11-	<0.001*
Female	117.97 ± 12.32	92.13-	
S.D.-Standard deviation, *-Statistically significant			

Table 2: Comparison Of Pubic Length & Ischial Length/Height.

Authors	Race	Pubic Length (cm)		Ischial Length/ Height (cm)	
		Males(n)	Females(n)	Males(n)	Females(n)
Washburn (1948) [12]	Whites	7.38(100)	7.79(100)	8.84(100)	7.83(100)
Washburn (1948) [12]	Negroes	6.92(50)	7.35(50)	8.66(50)	7.75(50)
Washburn (1949) [10]	Bantu	6.62(82)	7.32(70)	8.03(82)	7.48(70)
Washburn (1949) [10]	Bushman	6.04(26)	6.68(29)	7.22(26)	6.69(29)
Hanna & Washburn (1953) [17]	Eskimos	7.41(129)	8.01(95)	8.84(129)	8.10(95)
Davivongs (1963) [2]	Australian Aborigines	6.33(89)	6.92(72)	8.12(89)	7.47(72)
Orban (1980) [9]	French & Belgian	8.79(40)	8.90(36)	8.92(46)	8.0(53)
Rissech et al (2003) [17]	London, Coimbra, Lisbon	-	-	9.30(60)	8.47(50)
Rissech & Malgosa (2007) [11]	Iberian	7.94(64)	8.15(48)	-	-
Rissech & Malgosa (2007) [11]	Britannic	8.50(23)	9.04(22)	-	-
Present Study	North Indians	7.92(80)	8.56(20)	8.07(80)	7.31(20)

Table 3: Mean Pubic Length & Ischial Length In Different Primates [14].

Species	Pubic Length (cm)		Ischial Length/ Height (cm)	
	Males (n)	Females (n)	Males (n)	Females (n)
Sub-adult Hylobates lar	3.12 (10)	2.96 (7)	3.53 (10)	3.30 (7)
Hylobates lar	3.63 (100)	3.8 (87)	3.92 (100)	3.82 (87)
Hylobates moloch	3.69 (11)	4.10 (7)	3.89 (11)	3.80 (7)
Macaca	4.10 (28)	4.24 (41)	4.94 (28)	4.43 (41)
Ateles	4.10 (5)	4.49 (7)	4.56 (5)	4.44 (7)
Nasalis	4.88 (10)	4.35 (15)	5.65 (10)	4.49 (15)
Sub-adult chimpanzee	6.00 (4)	6.28 (5)	7.73 (4)	8.24 (5)
Chimpanzee	7.48 (21)	7.48 (30)	9.07 (21)	8.59 (30)
Orang-utan	8.51 (24)	7.97 (26)	8.69 (24)	7.45 (26)
Gorilla	12.33 (26)	10.12 (15)	13.17 (26)	10.30 (15)
Negro	6.92 (50)	7.35 (50)	8.66 (50)	7.75 (50)
North Indians (Present Study)	7.92 (80)	8.56 (20)	8.07(80)	7.31(20)

Table 4: Comparison Of Ischiopubic Index.

Authors	Race	Males (n)	Females (n)
Washburn (1948) [12]	Whites	83.6 (100)	99.5(100)
Washburn (1948) [12]	Negroes	79.9 (50)	95.0 (50)
Washburn (1949) [10]	Bantu	82.5 (82)	98.1(70)
Washburn (1949) [10]	Bushman	83.7(26)	100.0 (29)
Hanna & Washburn (1953) [18]	Eskimos	83.9 (129)	98.8 (95)
Davivongs (1963) [2]	Australian Aborigines	77.98 (89)	92.72 (72)
Pal et al (2004) [19]	Uttar Pradesh	89 (62)	100 (143)
Present Study	North Indian	98.28 (80)	104.24 (20)

Table 5: Influences Of Age & Sex On Ischiopubic Index [12].

AGE	SEX	Change in character	IP Index
Foetus & Infant	Both	No sex difference in length of pubic bone	Averages 83% in both sexes
3-7 years	Males	In infant, juvenile & adult, ischium & pubis bear same relation to each other	Remains same-(82-83%)
	Females	Departure from infant relation , caused by ischium being slightly shorter and the pubis longer	Remains same-(85-86%)
7 Years	Males	Ischium Pubis relations remain constant	Constant
	Females	Female pelvic inlet grows rapidly due to an increase in pubic length(Hormonal Basis)	Exceeds the childhood mean by 14%

Table 6: Mean Ischio-Pubic Index In Different Primates [14].

Species	Males (cm)	Females (cm)
Presbytis	68	91
Chimpanzee sub-adult	77.6	76.2
Treachypithecus	80	102
Chimpanzee	82.6	87
Macaca	82.9	95.7
Macaca	84	105
Nasalis	86.4	96.9
Hylobates sub-adult	88.3	89.6
Ateles	89.9	100.8
Hylobates	92.7	101.6
Gorilla	93.6	98.3
Orang-utan	97.8	107.1
Negro (Washburn,1948)	79.9	95
White (Washburn,1948)	83.6	99.5

The observations of the three parameters pertaining to the Ischiopubic region of the hip bone have been depicted in Table I, which shows the mean values and range in males and females, irrespective of the sides. The p-values between the mean values of the two sexes have also been given in the table.

1. Pubic Length: It was found to be 7.92 $\pm$ 0.71 cm (Range 5.63-9.34 cm) in males & 8.56 $\pm$ 0.47 cm (Range 7.75 – 9.53 cm) in females, the difference between the means of the two sexes being statistically significant (p-value < 0.001).

2. Ischial Length: It was found to be 8.07 $\pm$ 0.57 cm (Range7.04-9.40 cm) in males & 7.31 $\pm$ 0.78cm (Range 6.02-8.77 cm) in females, the difference between the means of the two sexes being statistically significant (p-value < 0.001).

3. Pubo- Ischial Index: It came out to be 98.27 $\pm$ 7.33(Range 70.11-122.71) in males & 117.97 $\pm$ 12.32 (Range 92.13-139.18) in females, the difference between the means of the two sexes being statistically significant (p-value < 0.001).

DISCUSSION

Sex differences in the human pelvis are well defined in a vast literature which includes contributions from anatomists, anthropologists and gynaecologists. [8] A study of the pubic length, ischial length & their index in the North Indian population provides us information regarding the racial & sexual differences in the pubis & Ischium. Further these parameters have been compared with the other primates.

1. Length of Pubic Bone: As seen in the observations (Table 1), pubis was significantly longer in females as compared with males in the North Indian population.

A look at Table 2 clearly shows that when compared between the two sexes, pubic length is always more in females as compared to males in all the races. However amongst different races, it is maximum in French & Belgian [9] and minimum in Bushman [10]. It can also be seen that the North Indian values are closest to the Iberian races [11].

Washburn (1948) [12] is of the view that since pubic region is most responsive to sex hormones, the pubic length is the best indicator of sex determination of a skeleton, the other indicators like subpubic angle, height of pubic symphysis and shape of obturator foramen being secondarily dependent upon it. As the pubic length increases; the subpubic angle becomes wider, height of symphysis decreases and obturator foramen becomes more triangular.

He further reiters that using pubic length as a sex indicator is more advantageous as it not only gives an estimate of primary variable and is easier to measure than the subpubic angle, but also avoids practice of counting same difference over and over again in different forms and can be done on a single bone, not requiring an articulated pelvis. Moreover this length is of specific value to archaeologists working with fragmentary remains.

He also added that pubic bone in its selective deposition & remodeling of the pelvis, affects both sagittal & transverse diameters of inlet. He expressed the belief that pubis, more than any other bone, causes sex differences in these dimensions, for it is most responsive to female sex hormone [13].

The action of oestrogens on osteoblastic activity is now well known. Knowledge of steroidogenesis clearly indicates that not only there are marked variations in the amount of hormone produced, but that other factors influence the effective circulating levels which act at sensitive end organs [8].

Phylogeny: Schultz (1949) [14] compared pubic length in different primates (See Table 3) & concluded that in most of them, it is more in

females as compared to males except in Sub-adult Hylobates, Nasalis, Orang-utan, & Gorilla. The only exception is chimpanzee where there is no sex difference in the average pubis length. He further commented that:

i. Any enlargement in the pelvic ring of the female may be a necessary requirement for the successful passage of newborn & it is a result of natural selection.

ii. Sex differences in the pelvis may be an integral part of the general secondary sex differentiation, affecting bodily structures among primates, and this is widely different in different species.

In all monkeys studied and in man, the proportionate length of the pubis, the relative breadth of the pubis and the relative breadth of the pelvic inlet become significantly increased after sexual maturity in females and for all these primates it can be claimed that this enlargement represents a very essential adaptation in view of the proportionately large size of their newborns.

2. Height of Ischium: Ischium was significantly longer in males as compared to females in the North Indian population (Table 1).

As is evident in Table 2, the height of ischium is universally more in males than in females in all the races. When compared amongst the races, the values in North Indian population were in consonance with Bantu [10] and Australian Aborigines [2].

Phylogeny**:** Schultz (1949) [14] compared the ischial length in primate series [See Table 3] and found that as in humans, except for subadult Chimpanzee, in all other species, this parameter was larger in males as compared to females.

It was Washburn (1948) [12] who first put forward the view that Ischial height is proportional to the overall body size and reflects robusticity of male skeleton. Later, Leuteneggar (1970) [15] demonstrated a significant correlation between ischial length and body size.

Recently working further on the same subject, Rissech & Malgosa (2007) [11] not only supported the earlier workers but also revealed that the significant sexual dimorphism in ischial height appears at the age of 20 years due to longer growth period in males i.e. 25 years as compared with 20 years for females.

3. Ischiopubic Index: A look at Table 4 shows that the Ischiopubic index is universally more in females as compared to males. The same was true for present study also where it was significantly more in females (Table 2).

Another look at the Table 4 indicates that if the values of the same sex are compared amongst different races, these are also highly variable because of the racial influence on the ischial & pubic lengths.

Washburn (1948) [12] named this index as "Washburn Index" and gave the reason for using it for sexual dimorphism that the difference in the length of ischium is roughly proportional to the difference in size but the pubic bone is proportionately longer in females as it is most responsive to female sex hormones. He further delineated the influence of age and sex on Ischiopubic index. (See Table 5) Washburn (1949) [10] emphasizing upon the importance of the ischiopubic index and width of greater sciatic notch, asserted that sex of over 98 % of skeletons could be determined using these two indicators. Phylogeny: Schultz (1949) [14] compared the Ischio-pubic Index in a primate series and as in humans found it to be more in females in all of them except sub-adult chimpanzee. (See Table 6)

Similarly in another study by Mobb & Wood (1977) [16] on 8 taxa of primates i.e. Homosapiens, Colobus, Presbytis, Cercopithecus, Gorilla, Pan, Papio & Cercocebus it was found to be more in females as compared to males even though pubic length showed less growth in females of Gorilla, Pan, Papio & Cercocebus as compared with their male counterparts.

CONCLUSION

Of those parts of the postcranial skeleton which are so important for the sex diagnosis of pre-historic remains, one of the two hip bones is usually sufficiently well preserved. This gives an insight into particular significance attached to hip bone in sex classification [6]. The present study has provided a detailed study of the three statistically significant, sexually dimorphic parameters which might serve in sex determination even when fragmentary remains of hip bone are available to comment upon the sex of the dead & decomposed skeletons.

Conflicts of Interests: **None**

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