Sex Determination using the Ischiopubic Index in South Indian Population

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Abstract

The aim of this study was to use the Ischiopubic index to explore the sex differences in the pelvis between the male and female bones. The pelvis is characterized by sexually dimorphic features and thus it can be used for sex determination while establishing the biological profile in unknown skeletal remains. In this study we have assessed the sex prediction potential of the Ischiopubic index using 72 dry innominate hip bones (38 male and 34 female) belonging to South Indian population. The lengths of the pubis and ischium were measured in these bones and the Ischiopubic index was calculated as per Washburn's formula. The Ischiopubic index was calculated to be 85.46 ± 3.63 mm. in males (Range 74.15 - 95.28 mm.) and 97.75 ± 4.10 mm. in females (Range 89.56 - 116.37 mm.). Application of the Student's t test showed that there was a statistically significant difference in the Ischiopubic index between the male and female pelvic bones with a $p < 0.001$.

Keywords: *Pubic length, Ischial length, Ischiopubic index, Sex determination, South Indian population*

Introduction

The overarching goal of the forensic pathologist when confronted with undocumented skeletal remains is establishing the biological profile and thus confirming the identity of the decedent individual. Estimating the sex from skeletal remains is a key step in the identification process in this context and it is often the first component of the biological profile to be assessed owing to the fact that other aspects of identification such as age, stature, and ancestry are in turn dependent on the estimation of sex.[1] Furthermore, an incorrect estimation of sex precludes correct identification for the simple reason that if the estimation is erroneous, this will in turn mislead the investigators into looking into the wrong half of the population. Given the importance of sex in reconstructing the biological profile, forensic experts are engaged in research to improve the accuracy of sex estimation.[2,3]

There are several regions of the skeleton that can be utilized to estimate sex, including the cranium, however they pale in comparison to the pelvis.[4-6] The pelvis is generally accepted as the most sexually dimorphic region of the human skeleton thus making it the ideal bone for sex estimation.[7-10]The marked sexual dimorphism in the size and shape of the pelvis is a consequence of the adaptation of the pelvic bone in females to facilitate the biological function of parturition. A human maternal pelvis must be large enough to enable birth of a large-headed neonate under the constraints of maintaining optimal bipedal biomechanics. The very specific obstetric function of the pelvis is responsible for inhibiting drastic intrasexual variation in morphology.[11-14] These sexually diagnostic features begin to clearly exhibit themselves in the pelvis during adolescence and are most pronounced in late adolescents and adults.

The two main methodological approaches to sexing skeletal remains using skeletal traits are morphological analysis and metric analysis. More recently a more sophisticated approach using Geometric morphometric analysis has been used to do sexing of bones[15]. In this method, morphological features are converted into a quantifiable entity using three-dimensional scanning and coordinate mapping.

A study of the morphological traits focuses on the shape of the bone i.e. bony configurations that are macroscopically visible.[7,16-17] This approach is advantageous in that a particular form may be recognizable despite interpopulation variations and changes that occur over time. However, there is an element of subjectivity in this approach and the outcome cannot be ascertained with precision. Most of the older studies pertaining to sexual dimorphism employed this method. The most commonly used visual method of sex estimation from the pelvis is the one advocated by Phenice which involves examination of three traits of the pubic bone[7]. These three traits include the ventral arc, subpubic concavity, and medial aspect of the ischiopubic ramus on the pubic bone.

The second method is the metric method which is based on taking measurements of various dimensions of skeletal material which are prone to dimorphism.[12] Metric methods offer several advantages over the morphological methods. First, inter- and intra-observer error and subjectivity are typically lower in this type of analysis.[18] Second, they are more reproducible than morphological methods because they rely on standardized osteometric landmarks which are easy to locate and are more objective than non-metric methods because the landmarks are easier to locate and their assessment is not based on judgment. Examples of such metric methods applicable to the pelvis are the length of the pubis, length of the ischium, diameter of the acetabulum etc. These metric measurements can be transformed into indices such as the Ischiopubic index, the Sciatic notch index, Acetabulopubic index which can be subjected to statistical analysis. Metric analysis, however, despite its high level of objectivity and reproducibility, has its limitations.[17] Metric methods are population specific and the indices have to be established for each population. They have a tendency to yield error owing to the fact that they are dependent on absolute differences in measured dimensions of skeletons.

Washburn provided the first popularly utilized index, the Ischiopubic index.[12] He conducted pioneering studies on the differences between the sexes for the pubic and ischial bones using documented skeletal material of American White and Black adults from the Hamann-Todd collection held at the Natural History Museum in Cleveland. Washburn found both sex and populational differences, with the sex determination reliability rate over 90% when using the Ischiopubic index. In this study we have explored the utility of the Ischiopubic index in pelvic bones belonging to south Indian population.

Materials and Methods

The material for the study comprised of a total of 72 intact dry pelves of documented gender (38 male and 34 female bones) sourced from the skeletal collections in the Departments of Forensic Medicine and Anatomy at Chettinad Hospital and Research Institute (CHRI). The bones used for the measurements were intact, devoid of pathology, fracture or wear and tear. A digital sliding caliper was used for making measurements up to a least count of 0.01 mm.

This study entailed a correct identification of the acetabular landmark which serves as the base point for making the measurements. The acetabular landmark as described by Schulz is located in the anterior aspect of the bone and can be identified as an irregularity, a change in bone translucency or a notch.[19] This base point in the acetabulum was carefully located in each bone using the Schulz criteria before making the measurements.

The measurements made were the length of the pubis and the length of the ischium as described in standard protocols and defined as follows:[12,16]

Length of the Pubis: The greatest distance from the acetabular landmark to the symphysial surface of the pubis. While measuring the pubis, care was taken to hold the sliding calliper parallel to the long axis of the bone as detailed in the standard protocols.

Length of the Ischium: The greatest distance from the point in the acetabulum to the farthest point on the ischial tuberosity which is also called the Ischial point.[20]

The Ischiopubic index was calculated by using the equation of Washburn as follows:

$$\text{Ischiopubic Index} = \frac{\text{Length of the Pubis} \times 100}{\text{Length of the Ischium}}$$

Results

The lengths of the pubis and ischium were measured to the nearest 0.01 mm. with the help of a digital sliding

calliper and the Ischiopubic Index was calculated. A statistically significant difference was not observed in the values between the right and left side in both sexes and thus the data for the two sides was pooled. Computational and statistical analysis of the results was done using the SPSS software version 21 through which the mean and standard deviation (S.D.) were calculated for all three parameters. In addition, a calculated range was arrived at using mean ± 3S.D. and from this the demarcating point was established.

The range, mean, standard deviation, calculated range and the demarcating points for all three parameters are depicted in tables 1 and 2.

Length of Pubis:

The mean pubic length was found to be 74.26 ± 3.36 mm. in males (Range 62.14-85.23 mm.) and 80.28 ± 4.57 mm. in females (Range 65.76-91.36 mm.). The p value was found to be <0.001 thus implying that the difference in length between the male and female bones was statistically significant.

Length of Ischium:

The mean ischial length was found to be 80.55 ± 5.23 mm. in males (Range 70.16-93.23 mm.) and 77.49 ± 4.51 mm. in females (Range 63.35-87.63 mm.). The p value was found to be <0.001 thus implying that the difference in length between the male and female bones was statistically significant.

Ischiopubic Index:

The Ischiopubic index was calculated to be 85.46 ± 3.63 in males (Range 74.15 ± 95.28) and 97.75 ± 4.10 in females Range (89.56 - 116.37). The p value was found to be <0.001 thus implying that the difference in length between the male and female bones was statistically significant.

Table 1: Statistical analysis of Pubic Length & Ischial Length

Statistical Parameter	Pubic length (mm.)		Ischial length (mm.)	
	Male	Female	Male	Female
Range	62.14-85.23	65.76-91.36	70.16-93.23	66.35-87.63
Mean	74.26	80.28	80.55	77.49
Standard Deviation (S.D.)	3.36	4.57	5.32	4.51
3 S.D.	10.08	13.71	15.96	13.53
Calculated Range [Mean ± 3 S.D.]	64.18-84.34	66.57-93.99	64.59-96.51	63.96-91.02
Demarking Point	<66.57	>84.34	>91.02	<64.59

Table 2: Statistical analysis of Ischiopubic Index

Statistical Parameter	Ischiopubic Index	
	Male	**Female**
Range	74.15-95.28	89.56-116.37
Mean	85.46	97.75
Standard Deviation (S.D.)	3.63	4.10
3 S. D.	10.89	12.3
Calculated Range [Mean ± 3 S.D.]	74.57-96.35	85.45-110.05
Demarking Point (D.P.)	<85.45	>96.35
% of bones whose sex was identified using D.P.	35%	92%

Discussion

Analysis of the results obtained (refer tables 1 and 2) showed that the mean pubic length was greater in female pelvic bones when compared to males. The mean ischial length on the other hand was greater in males than in female pelvic bones. These findings are in agreement with that of researchers who have studied other ethnic populations. The results of our study, i.e. the pubic length, ischial length and Ischiopubic index have been tabulated for comparison with that of other researchers (Refer Tables 3 & 4).

Until puberty, male and female pelvis exhibit only moderate sexual dimorphism. The pubic region is most responsive to sex hormones and with the onset of puberty the sex-specific rise in oestradiol levels triggers a change in pelvic bone remodelling patterns.[21] Thus, there is a growth spurt in the feminine pubic length, resulting in rapid expansion of obstetrically relevant pelvic dimensions up to the age of 25–30 years. In the course of this growth spurt, the pubis grows faster than the ischium and this in turn increases the Ischiopubic index to a greater degree than in females than in males. The most significant sexual differences in the ischiopubic area are due to the feminine pubis length growth spurt.

The mean Ischiopubic index calculated in our study is higher in female pelvic bones and this confirms the findings reported by several other researchers. While there is a concordance in the pattern, the results show a significant difference in the actual mean values and demarking point between our study and that of other ethnic groups and this could be accounted for by various factors like heredity, race, climate, geographical variations etc. Thus, every population has its own metric standard values.

Table 3: Comparison of Ischiopubic Index in our study with that of other researchers

S. No.	Researcher	Ischiopubic Index			
		Range		Mean	
		Male	Female	Male	Female
1.	Present Study	74.15-95.28	89.56-116.37	85.46	97.75
2.	Adhvaryu A. V.22	86.84-116.92	101.2-136.07	100.52	115.52
3.	Kushal K. D.23	74.31-97.43	82.91-116.5	86.55	99.55
4.	Nirmala V. K.24	84.75-138.08	98.93-147.91	116.87	128.14
5.	Sandhya K.25	65.71-96.08	73.48-98.42	76.72	85.87
6.	Sachdeva K.26	70.11-122.71	92.13-139.18	98.27	117.97
7.	Jani C. B.27	77.01-97.53	88.39-108.96	86.72	96.87
8.	Sharma G. K.28	64.2-97.46	84.43-111.76	78.79	96.76
9.	Singh S.29	80.37-91.51	92.38-120.82	87.19	105.13

Table 4: Comparison of Average Pubic Length and Ischial Length in our study with that of other researchers

S. No.	**Researcher**	**Average Pubic Length (mm.)**		**Average Ischial Length (mm.)**	
		Male	**Female**	**Male**	**Female**
1.	Present Study	74.26	80.28	80.55	77.49
2.	Adhvaryu A. V.22	74.03	77.55	73.67	67.16
3.	Kushal K. D.23	75.32	78.89	81.36	78.44
5.	Sandhya K.25	66	66.8	86.6	78.2
6.	Sachdeva K.26	79.2	85.6	80.7	73.1

Conclusion

In conclusion, the present study has established the presence of statistically significant sexual dimorphism in the Ischiopubic index of South Indian population and comparison of the findings with that of other researchers also points to racial and regional variation. This underscores the need for each population group to have specific standards to optimize the accuracy of identification. The study attests to the utility of the Ischiopubic index in case of undocumented remains brought to the forensic expert for biological profiling given the need for more precise methods of identification from the skeleton because of the increasing number of decomposed remains that confront law enforcement agencies. The findings of this study are thus important in that they contribute to the database of anthropologically and obstetrically significant data for South Indian population and would also help in identifying unknown skeletal remains.

Conflict of Interest: None declared

Source of Funding: Nil

Informed Consent: Not applicable

Ethical Clearance: Not required as the study was done on bone specimens

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