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Research Article

Pelvic bone indices as effective parameters of sex determination in skeletal remains: a cross-sectional study

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ABSTRACT

Background: With racial differences, it's difficult to implement a uniform method for determining sex. Therefore, the need for present study to be carried out was felt. An attempt has been made by carrying out this study to arrive at appropriate conclusions regarding sex determination using dry hip bones representing South-Eastern India (Kancheepuram district region of Tamil Nadu) in relation to the two important indices, the Coxal index (CI), and the Genoves' sciatic notch index(GSI).
Methods: Material for the cross-sectional study included 25 dry hip bones of known gender (left sided were 14, right were 11, male hip bones were 15, and female were 10). Coxal index, Genoves' sciatic notch index, Mean and standard deviation (SD) for the indices were calculated. Significance of these indices in sex determination of the hip bones was assessed implementing unpaired t test.
Results: When unpaired t test was applied on the mean and standard deviation of Coxal & Genove's sciatic notch indices of the two groups, Males (n=15) & Females (n=10), the result was statistically very significant.
Conclusions: Coxal index values of our present study can be reliably applied for sex determination of dry hip bones of Indian origin. But, our study values can be considered more reliable when using Genoves' sciatic notch index in determining sex of hip bones of South-Eastern region only (keeping racial variations in mind).

Keywords: Pelvic, Coxal, Genoves' sciatic notch index

INTRODUCTION

Pelvic bone, generally known as hip bone, is supposedly the most important bone in determining the sex of an individual. Determination of sex of an unknown individual is one of the critical questions addressed when human skeletal remains are found both in forensic investigation and studies of past population. Like any other bone, pelvic bone too isn't free of debate when it comes to sex determination using the bone. Therefore the study of sexual dimorphism of bones in human population is a matter of interest not only for Anatomists but also for the Anthropologists and Forensic experts.[1] Sexual dimorphism of hip bone is a special adaptation in the females for child bearing. Therefore, awareness of the average dimensions of the hip bone in both sexes will also help in early detection of disputed sex by forensic experts.[2]

In the past, many workers have evolved various metrical parameters and indices for sexing of hip bone, Derry,[3] Sraus,[4] Jovanovic and Zivanovic,[5] Jovanovic et al,[6] Singh and Potturi,[7] Schulter Ellis,[8] Turner,[9] Pal et al.[10] Racial differences in Thais, Chinese, Nigerians and other

populations have been compared by Varodompun et al[11] and Msamati et al.[12] Various metrical parameters for hip bone have also been reported by Washburn et al[13] and Davivongs et al.[14] With racial differences, it's difficult to implement a uniform method for determining sex. Therefore, need for the present study to be carried out was felt. However, it being the most useful bone when it comes to sex determination, more research is required to arrive at conclusions regarding sex determination using the bone. The present study will hence provide valuable parameters in the Indian population which would help the forensic experts, anthropologists and orthopaedicians. Shah et al[15] and Singh et al,[16] by their studies, considered Coxal index (CI) and Genoves' sciatic notch index (GSI) of hip bones very valuable parameters in determining sex, in North-Western India. An attempt has been made by this study to arrive at appropriate conclusions regarding sex determination using hip bones representing South-Eastern India (Kancheepuram district region) in relation to the two important indices, the Coxal index (CI), and the Genoves' sciatic notch index (GSI).

METHODS

The study was cross-sectional, and was conducted during the months of July and August, 2014. Material for the study consisted of 25 dry hip bones of known gender (left sided were 14, right were 11, male hip bones were 15, and female were 10). Gender was assessed by examining important parameters like Pubis and obturator foramen shape, acetabular diameter, greater sciatic notch shape and presence of pre auricular sulcus All the bones were fully ossified (adult) bones and free from any pathological or congenital defect (Figure 1). The study was conducted on bones from teaching collection of the Anatomy department at Karpaga Vinayaga Institute of Medical Sciences And Research Centre, Kancheepuram, Tamil Nadu. Fully ossified, dry and intact hip bones of known gender were included. Deformed and malformed bones with congenital anomalies and sexual dimorphism were excluded from the study. *With 26 bones available, 1 was excluded by implementing exclusion criteria. Keeping Confidence Level at 95% and Confidence Interval at 3, sample size was determined as 25 hip bones.*

Figure 1: Study material - fully ossified, adult, dry hip bones, free from any pathological or congenital defect.

Hepburn's osteometric board and scale were used for measurements. *Length*, the maximum distance from the most superior point on the iliac crest to a plane drawn along the inferior surface of the ischium, was measured with the help of the osteometric board, and the measurements were recorded in centimeters. The most superior point of the iliac crest was placed in contact with the fixed end of the board and the inferior surface of the ischium was placed against the movable arm (Figure 2). *Width*, the maximum distance between the anterior superior iliac spine and the posterior superior iliac spine, was measured with the help of an osteometric board and the measurements were recorded in centimeters. The posterior superior iliac spine was placed in contact with the fixed end of the board and the anterior one was placed against the movable arm (Figure 3). *Coxal Index* was calculated using the observed values of length and width of the hip bones. Formula used for calculating the Coxal Index was, "Width of hip bone/ length of hip bone x 100".

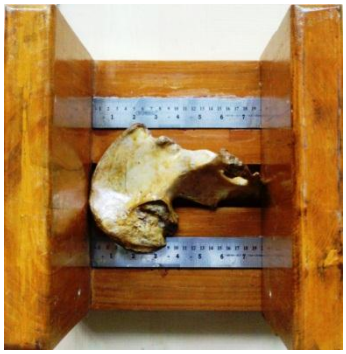

Figure 2: Length measurement with the help of Hepburn's osteometric board.

Figure 3: Width/Breadth measurement with the help of the osteometric board.

To calculate Genoves' sciatic notch index (GSI,) four points were marked on a plain sheet with hip bone placed on it. Point A denoted Piriformis tubercle, Point B denoted tip of Ischial spine, Point C denoted Point on AB with perpendicular line drawn from point D to AB, and Point D denoted deepest point on Greater sciatic notch (Figure 4). With the help of a scale, lines were drawn connecting the points. Maximum width of the Greater sciatic notch was

AB, Maximum depth was CD, and Posterior segment was AC. Posterior segment (AC) of the width is the segment Posterior to the point C. Genoves' sciatic notch index (GSI) was calculated using the formula, "Breadth/width of the Greater Sciatic notch (AB) ×100 / Length of Posterior segment of sciatic notch (AC)".

Figure 4: Greater sciatic notch boundaries highlighting points A, B, C & D.

Coxal index, Genoves' sciatic notch index, Mean and standard deviation (SD) for the indices were calculated. The hip bones were categorized into 2 groups, Males (n=15) and Females (n=10). Significance of these indices in sex determination of the hip bones was assessed implementing unpaired t test. Significance of the hip bone being right sided or left, in sex determination, was also assessed implementing the same test. This time, hip bones were categorized into Left sided (n=14) & Right sided (n=11).

RESULTS

Various parameters like Pubis and obturator foramen shape, acetabular diameter, greater sciatic notch shape and presence of pre auricular sulcus were studied (Table 1). Pubis shape & greater sciatic notch were the only ones without dimorphism. Rest other parameters had dimorphic features. However, in case of pre-auricular sulcus, its presence is useful. But its absence can be a feature of any of the two genders.

Table 1: Important parameters used to determine gender of the hip bones.

Variable	Male Feature (N)	Female Feature (N)	Dimorphic (N)
Pubis Shape	15	10	0
Obturator Foramen Shape	14	8	3
Acetabular Diameter	13	7	5
Greater Sciatic Notch Shape	15	10	0
Pre-Auricular Sulcus	0	5	20

When unpaired t test was applied on the mean and standard deviation of Coxal Indices of the two groups, Males (n=15) & Females (n=10), the two-tailed P value equaled 0.0019. By conventional criteria, this difference was considered to be *statistically very significant*. When tested on the mean and standard deviation of Genove's sciatic notch indices of the two groups, the two-tailed P value was less than 0.0001, which meant *statistically extremely significant* (Table 2). With mean and standard deviation of Coxal Indices of the two groups, Left (n=14) & Right sided (n=11) hip bones, the two-tailed P value equaled 0.9253 and was considered to be *not statistically significant*. And when tested on the mean and standard deviation of Genove's sciatic notch indices of the two groups, left & right sided hip bones, the two-tailed P value equaled 0.3111 and was considered to be *not statistically significant* again (Table 3).

Table 2: Unpaired t test with Male & Female Hip bones.

Variable	Groups	N	Mean	Standard Deviation (SD)	The Two Tailed P Value
Coxal Index	Males	15	67.7	2.6	P value = 0.0019 (Statistically very significant)
	Females	10	70.8	1.2	
Genove's Sciatic Notch Index	Males	15	380.6	62.3	P value < 0.0001 (Statistically extremely significant)
	Females	10	187.3	17.9	

Table 3: Unpaired t test with Left & Right Hip bones.

Variable	Groups	N	Mean	Standard Deviation (SD)	The Two Tailed P Value
Coxal Index	LEFT	14	68.9	2.9	P value = 0.9253 (Statistically not significant)
	RIGHT	11	69	2.2	
Genove's Sciatic Notch Index	LEFT	14	323.1	117.2	P value = 0.3111 (Statistically not significant)
	RIGHT	11	278	94.9	

DISCUSSION

In our present study, we derived the values of the Coxal & Greater sciatic notch indices, and found these values to be statistically very significant with the application of unpaired t test. On comparing the values of these indices elicited by our study, with the studies by Singh et al[15] and Shah et al,[16] the Coxal index values were almost similar with the study by Singh et al. But Shah et al reported higher values for Genoves' sciatic notch index in their study. This means, Coxal index values can be reliably

applied for sex determination of hip bones of Indian origin. But, when it comes to Genoves' sciatic notch index, one has to be cautious using it while opining for sex of a hip bone. May be, minor racial alterations in hip bones of these regions are responsible for variation in the index values. Thus, when using Genoves' sciatic notch index in determining sex of hip bones of South-Eastern region, our study values can be considered more reliable, and in North-Western region, study values by Shah et al can be considered more reliable for Genoves' sciatic notch index.

In our study, we elicited statistically by unpaired t test that variation in the values of these indices was not significant between the hip bones of left and right side. Thus, the values of the indices elicited by our study can be used universally for both the sides of the hip bones. Pre- auricular sulcus is undoubtedly a very important feature in determining sex. Need to determine the significance of pre-auricular sulcus wasn't felt because it's well known that the presence of a prominent Pre-auricular sulcus is *almost* a sure shot indicator for female sex, as it's very rare for a male hip bone to have a pre-auricular sulcus. However, absence of pre-auricular sulcus does not determine male sex for obvious reasons. That is, prominent pre-auricular sulcus is a result of muscular activity during pregnancy and labor, and thus may be absent in females who haven't experienced the same. In our study 50% of females had pre-auricular sulcus, and 50% didn't. None of the males had it. Its absence was considered a dimorphic feature.

CONCLUSION

With two-tailed P values being statistically very significant in our present study, Coxal index values can be reliably applied for sex determination of hip bones of Indian origin. But, our study values can be considered more reliable when using Genoves' sciatic notch index in determining sex of hip bones of South-Eastern region only (keeping racial variations in mind), and in North-Western region, study values by Shah et al can be considered more reliable for Genoves' sciatic notch index. In our study, we elicited statistically by unpaired t test that variation in the values of these indices was not significant between the hip bones of left and right side. Thus, the values of the indices elicited by our study can be used universally for both the sides of the hip bones.

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