Original Article

A Morphometric Study Of The Acetabulum Of Dry Hip Bone In Relation To Sexual Dimorphism In North Indian Population

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Abstract

Background: The hip bone is a big, flattened, asymmetrical bone that is narrowed in the middle and enlarged above and below. Together, they form the sides and anterior wall of the pelvic cavity. It meets its counterpart on the opposing side in the middle line in front. **Aim: M**orphometric study of the acetabulum of dry hip bone in relation to sexual dimorphism in north Indian population. **Method:** The study is cross sectional. Material for the study consisted of 300 dry hip bones of known gender. Gender was determined using information from the Department of Anatomy Index Medical College Malwanchal University Indore M.P. All the bones are fully ossified and free from any congenital or pathological defects. Deformed and malformed bones are also excluded from the study. Not properly ossified and not paired bones were excluded. **Results and Conclusion:** The vertical, transvers, anterior, posterior diameter and depth of acetabulum were found significant difference between male and female.

Keywords: hip bone, acetabulum

Introduction

The hip bone is a big, flattened, asymmetrical bone that is narrowed in the middle and enlarged above and below. Together, they form the sides and anterior wall of the pelvic cavity. It meets its counterpart on the opposing side in the middle line in front. In a young subject, the ilium, ischium, and pubis are separate from one another; in an adult, they are fused together. The union of the three components occurs in and around the acetabulum, a huge cup-shaped articular cavity that is located close to the middle of the outer surface of the bone. The superior broad and extended section that rises upward from the acetabulum is known as the ilium and is given that name because it supports the flank. The ischium, which extends downward from the acetabulum, expands into a large tuberosity, and then curves forward to form the obturator foramen, a large aperture, is the lowest and strongest part of the bone. The pubis forms the front of the pelvis and supports the external organs of generation as it extends medially forward and downward from the acetabulum and articulates in the middle line with the bone on the opposite side[1].

Structure of human pelvis:

The human pelvis is made up of the sacrum, the coccyx, and the two os coxae [2]. Each os coxae is made up of the ischium, ilium, and pubis, and the articulations within the pelvis are: inferiorly between the sacrum and the coccyx; (sacrococcygeal symphysis). While the SI joint does not allow for much movement during development, by adulthood it has evolved into the synarthrodial joint, which does[3]. A cartilaginous synarthordial joint and fibro cartilaginous interpubic disc make up the pubic symphysis[4]. Only a small amount of translation and rotation is possible with this articulation. The pubic symphysis moves in proportion to movements in the SI joint and vice versa.

The ilium is divided into two parts, the body and the ala; the arcuate line, which can be seen on the internal surface, and the edge of the acetabulum, which can be seen on the external surface, serve as markers for the division. The infer posterior, or ischium, of the innominate bone consists of a body and ramus. The femoral, posterior, and pelvic surfaces are located on the body's top and lower ends. The pubis forms a median cartilaginous pubic symphysis with its neighbour and is the ventral portion of the innominate bone. A superior ramus leaves its anteromedial body and travels up and back to the acetabulum, while an anteroinferior ramus departs from the same location and travels back, down, and laterally to connect with the ischial ramus inferomedial to the obturator foramen.

The acetabulum is a large, hemispherical depression that faces forward, to the side, and downward. A little less than two-fifths of it is given by the ilium, a little more than two-fifths by the ischium, and the remaining fifth by the pubis. It is created medially by the pubis, above by the ilium laterally, and below by the ischium. A tiny notch is formed by the posterior concavity as it descends from the PSIS in an erratic, forward direction. A wide low projection called the PIIS is located at the bottom of the notch. Together, these borders create a deep greater notch that is bordered by the ischium below and the ilium above. A large opening called the obturator foramen can be found between the pubis and the ischium. The female's is smaller and more triangular in shape while the male's is larger and oval in shape, with the longest diameter slanting backward from the front[1].

Articulation of pelvis: The three main hip ligaments (iliofemoral, ischiofemoral, and pubofemoral) offer support. As the hip extends, all three ligaments get harder. The ligaments and capsule of the hip are the stiffest when there is wide, little internal rotation, or abduction. The region of maximum bony congruency at most other joints is not the same as the location of highest ligamentous consistency at this joint. The hip's joint congruency is at its peak when the joint is flexed to 90 degrees. Other than the capsular hip ligaments, lesser ligaments may alter the hip joint's strength.

Muscles: Additionally, the muscles around the hip joint provide a lot of dynamic stability. While global muscles (muscles far from the axis of rotation) cause the joint to spin, local muscles (muscles close to the axis of rotation) may be able to stabilise the joints. Local muscles of the hip include the iliopsoas, gluteus medius & minimus, and deep external rotators[5].

The hipbone (os coxae) is regarded as the best bone for detecting sexual orientation due to its high degree of accuracy. It describes the general differences between men and women as well as how the female hipbone is altered prior to delivery. The accuracy of sex determination from the adult pelvis based only on morphology and morphometry is 95% [6]. A crucial stage in biological profiling or proving uniqueness from a severely charred corpse in forensic medicine is identifying the sex from skeletal remains[7]. Bones can be analysed anthropometrically to determine gender, size, age, and race. The hip bone is recognised as the primary bone in the body for sex identification due to the clear sexual dimorphism that manifests as reproductive effect and mobility in females and men. Sexual dimorphism is more prominent in the hip bone than in any other additional bone in the body because of changes in the pelvis during delivery. Male hip bones are the obturator foramen and the shallow iliac fossa, with their oval shapes and shallow shapes, respectively, in comparison to female hip bones. Male hip bones also differ from female hip bones in non-metric traits like eversion of the ischi opubic ramus. Because the pelvis in men and women is shaped differently, pelvic dimorphism developed. Locomotion and labour play many different functions. Because men are typically taller than women, allometry may contribute to some features of sexual dimorphism in pelvic form or individual variations in the link between size and pelvic shape. The intricate design of the human pelvis demonstrates its wide range of uses, including movement, childbirth, and support for the upper vertebral column. The considerable pelvic sexual dimorphism is related to obstetric function.

The pelvic canal in women is larger and structured differently than it is in men[8]. Sex variations in the pelvis have been discussed using both quantitative and visual assessments. Pelvic dimorphism has frequently been used to ascertain sex in forensic, anthropological, and archaeology research[9]. The amount of the sexually dimorphic pubis in the ischium and metric body size are linked by the ischium-pubic index, a conventional sex identification characteristic[10].

Its length and the sex dimorphic pubis, a measurement of body size, are directly correlated. It is believed that sex differences in the pelvic region exist. Only human female pelvises can accommodate the foetus during childbirth. Bipedal locomotion capacity and the capacity to accommodate obstetric requirements are thought to be two of the most significant selection variables for pelvic morphology. Males and females have distinct physical heights; typically, males are taller[11]. The GH/IGF-1 axis, steroid hormones, and puberty all contribute significantly to the development of both male and female body types. As a result, while the need for childbirth in females may account for some of the gender gap. The data suggests that differences in body weight between men and women could account for the remaining percentage[12,13,14]. However, the goal of this research is to ascertain how different hip bone characteristics relate to sexual dimorphism[14]. Estimating the biological profiles of individuals is challenging in the fields of forensic anthropology, paleoanthropology, paleodemography, and bioarcheology. Sex identification is one of the first and most crucial tasks in forensic or archaeological investigations[15]. The pelvic bone on the human skeleton has the most obvious sexual differences. They give sexually dimorphic characters a trustworthy sex assessment. However, just like the rest of the body, the skull offers defence[16].

Physical traits that differ across sexes. The cranium, on the other hand, has less sexual dimorphism than the hip bone. Additionally, the body17 maintains and stabilises this cranium better[17]. The pelvis is therefore more trustworthy in terms of sexual dimorphism. Morphometric approaches allow the assessment of changes in structural size in addition to being more objective. Aim of the study a morphometric study of the acetabulum of dry hip bone in relation to sexual dimorphism in north Indian population.

Materials and Method

The study is cross sectional. Material for the study consisted of 300 dry hip bones of known gender. Gender was determined using information from the Department of Anatomy Index Medical College Malwanchal University Indore M.P. All the bones are fully ossified and free from any congenital or pathological defects. Deformed and malformed bones are also excluded from the study. Not properly ossified and not paired bones were excluded.

The metric parameters were:

a. **Vertical Diameter of Acetabulum: -** was measured as farthest distance on acetabular margin in vertical plane with the help of vernier caliper.
b. **Transverse Diameter of Acetabulum: -** was measured as the farthest distance on acetabular rim in horizontal axis with the help of vernier caliper.
c. **Antero-Posterior Diameter of Acetabulum: -** was measured as the farthest distance on acetabular margin posterior axis with the help of vernier caliper[5].
d. **Depth of Acetabulum:** It is described as the maximum vertical distance from the brim of the acetabulum to the deepest point in the acetabular cavity. It will be measured using a vernier caliper. It can be measured by using a thin metallic strip placed across the brim of the acetabular cavity and then the distance from the metallic strip to the deepest point in the acetabulum using a vernier caliper. The readings were noted in centimeters.

All the measurements were taken with the help of vernier caliper, measuring cylinder and plasticine. Three readings were taken for each parameter at different times and the average will recorded. Range, mean, standard deviation and standard error of mean was determined for each parameter. All values were compared with series of other workers to draw the conclusions.

Results and Discussion

Statistical analyzes projected that the vertical diameter of acetabulum found to be significantly. This was observed that the average (Mean ± SD) was found in male 49.49 ± 3.26 and in female 46.23 ± 3.55. The vertical diameter of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001. These findings were in line with the findings of prior research conducted by

Rajashekhar et al., (2017)[18], Steyn et al. (2008)[19] they noted that the males' vertical acetabular diameter (50.85123967mm) was greater than the females' (47.22352941) and that the males' transverse acetabular diameter (48.1322314mm) was greater than the females' (45.24705882mm) and concluded that the diameter of the acetabulum was the single most dimorphic trait, offering, on average, 83.9% accuracy when employed alone.

Statistical analyzes projected that the **transverse diameter of acetabulum** found to be significantly. This was observed that the average (Mean ± SD) was found in male 50.46 ± 4.06 and in female 47.97 ± 4.15. The transverse diameter of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001. These findings were in line with the findings of prior research conducted by

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Statistical analyzes projected that the **anterior diameter of acetabulum** found to be significantly. This was observed that the average (Mean ± SD) was found in male 22.24 ± 1.89 and in female 29.3 ± 2.2. The anterior diameter of acetabulum was found significantly lower in male comparison to that in the female, with a p value of < 0.001. These findings were in line with the findings of prior research conducted by

Thomas et al., (2019)[20], Rajashekhar et al., (2017)[18] suggested that the anterior and posterior diameter of acetabulum significant in classifying the sexes and they were found a statistically significant difference between male and female and they noted that the females' anterior and posterior diameter of acetabulum was greater than the males.

Statistical analyzes projected that the **posterior diameter of acetabulum** found to be significantly. This was observed that the average (Mean ± SD) was found in male 7.30 ± 1.82 and in female 15.7 ± 4.19. The posterior diameter of acetabulum was found significantly lower in male comparison to that in the female, with a p value of < 0.001. These findings were in line with the findings of prior research conducted by

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Statistical analyzes projected that the **depth of acetabulum** found to be significantly. This was observed that the average (Mean ± SD) was found in male 47.5 ± 5.33 and in female 45.1 ± 4.40. The depth of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001. These findings were in line with the findings of prior research conducted by

Sridharan et al., (2019)[31], Sandhya K et al., (2019)[22] conducted a morphometric study of acetabulum in adult dry human pelvic bone and they observed that mean depth of the acetabulum was found significantly more in male as compare to female,

Table-1 Comparison of Vertical, Transvers, Anterior, Posterior diameter and Depth of Acetabulum.

Variable	Male	Female	p – Value

	(mm)	(mm)	
	Mean ± SD	**Mean ± SD**	
Vertical diameter of acetabulum	49.49 ± 3.26	46.23 ± 3.55	0.001
Transverse diameter of acetabulum	50.46 ± 4.06	47.97 ± 4.15	0.001
Anterior diameter of acetabulum	22.24 ± 1.89	29.3 ± 2.2	0.001
Posterior diameter of acetabulum	7.30 ± 1.82	15.7 ± 4.19	0.001
Depth of acetabulum	47.5 ± 5.33	45.1 ± 4.40	0.001

SD = Standard deviation

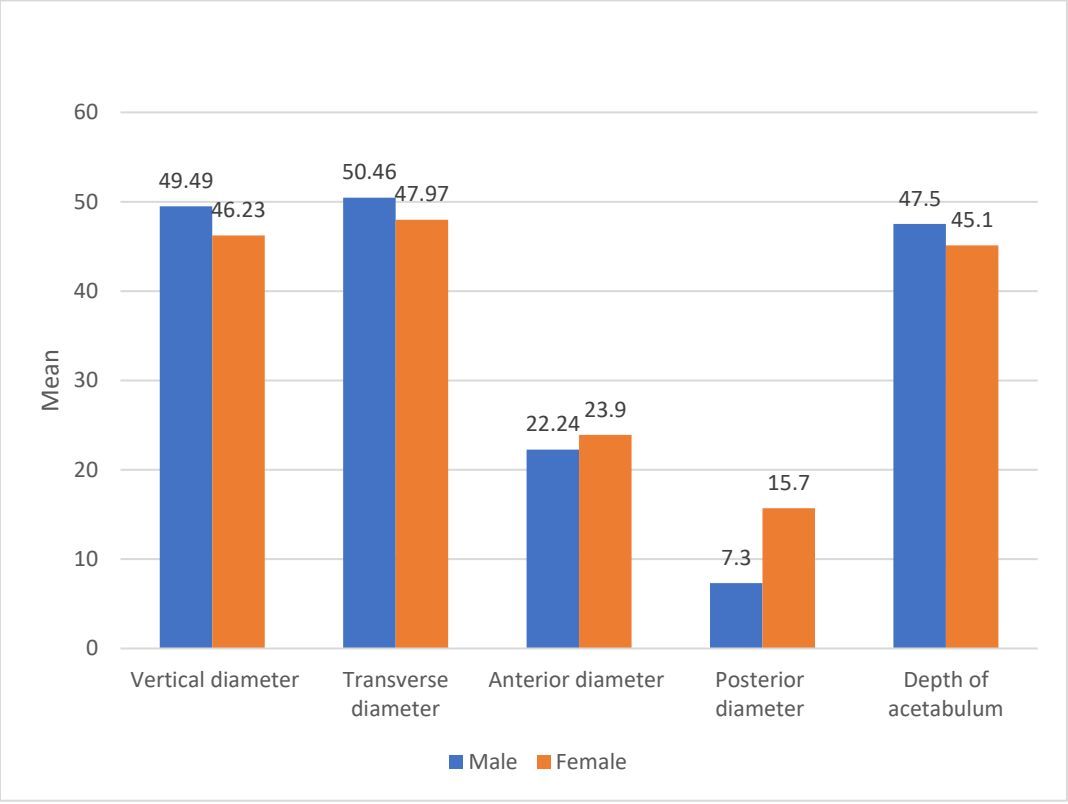

Figure:1 Comparison of Vertical, Transvers, Anterior, Posterior diameter and Depth of Acetabulum.

CONCLUSION

The findings of this investigation clearly demonstrate the hip bone considerable sexual dimorphism. The current study shows that all statistical methodologies are useful in determining sex, both individually and collectively. The accuracy of categorization improves as the number of parameters grows. Furthermore, the study's demarcating and limiting results can be used to establish baseline criteria for sex determination in the north Indian population.

The present study showed the following main findings:

1. The vertical diameter of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001.
2. The transverse diameter of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001.
3. The anterior diameter of acetabulum was found significantly lower in male comparison to that in the female, with a p value of < 0.001.
4. The posterior diameter of acetabulum was found significantly lower in male comparison to that in the female, with a p value of < 0.001.
5. The depth of acetabulum was found significantly higher in male comparison to that in the female, with a p value of < 0.001.

Males and females have distinct hip bone characteristics that can be measured. While the impacts of ageing are becoming more elusive and hidden, they are still observable within specific parameters. Male and female hip bone differences, as well as differences in age groups, have been shown to be statistically significant. Males are typically larger than females, and this disparity persists as people age. More research and studies are needed, based on the findings of this study, to definitely distinguish sex in the hip bone. When a hip bone is present, this information is likely to benefit forensic investigators in determining an individual's sex. More research, involving a broader range of populations and larger sample sizes, would undoubtedly contribute to the advancement of the scientific record.

The current study clearly shows that the males and females have statistically significance difference for all parameters. Anatomists and orthopaedic surgeons, as well as medico-legal professionals, benefit from these characteristics.

This research highlights the need of population-specific methodologies not only for medico legal investigations, but also for the study of population affinities and variables influencing bone shapes. When other human remains suitable for sex determination are unavailable, the study's findings may aid in predicting sex from the hip bone in Indians.

References:

1. Rissech, C., Estabrook, G.F., Cunha, E., and Malgosa, A. Estimation of ageat-death for adult males using the acetabulum, applied to four Western European populations. J Forensic Sci 2007; 52:774-778.
2. White, TD., Black, MT., Folkens, PA. Human osteology. Academic press; 2011.
3. Brooke R. The sacro-iliac joint. J Anat. 1924; 58(Pt 4):299–305.
4. Hagen R. Pelvic girdle relaxation from an orthopaedic point of view. Acta Orthop Scand. 1974; 45(1–4):550–63.
5. Retchford TH, Crossley KM, Grimaldi A, Kemp JL, Cowan SM. Can local muscles augment stability in the hip? A narrative literature review. J Musculoskelet Neuronal Interact. 2013; 13(1):1–12.
6. Krogman WM, Iscan MY. Determination of sex and parturition. In: The human skeleton in forensic medicine. Springfield: Charles CThomas publishers; 1986. p. 208–59.
7. Stewart TD. Sex determination of the skeleton by guess and bymeasurement. Am J Phys Anthropol 1954;12:385–9.
8. Schultz AH. 1949. Sex differences in the pelves of primates. Am J Anthropol 7:401–424.
9. Hanna RE, Washburn SL, Hanna RE, Washburn SL. 1953. Determinationof the sex of skeletons, as illustrated by a study of theeskimo pelvis. Hum Biol 25:21–27.
10. Schultz AH. 1930. The skeleton of the trunk and limbs of higherprimates. Hum Biol 2:303–438.
11. Grabowski MW. 2012. Hominin obstetrics and the evolution of constraints.Evol Biol 40:57–75.
12. Rogol AD, Roemmich JN, Clark PA. 2002. Growth at puberty.J Adolesc Health 31:192–200.
13. Styne DM. 2003. The regulation of pubertal growth. Horm Res 60:22–26.
14. Mobb GE, Wood BA. 1977. Allometry and sexual dimorphism in the primate innominate bone. Am J Anat 150:531–537.
15. Ferembach D, Schwidetzky I , Stloukal M (1980)Recommendations for age and sex diagnoses of skeletons. J HumEvol 9:517–549.
16. Özer BK, Özer I, Sagir M, Gülec E (2014) Sex determination using the tibia in an ancient Anatolian population. Mediter ArchaeolArchaeom 14:329–336.
17. Kemkes-Grottenthaler A (2001) The reliability of forensic osteology– a case in point: case study. Forensic Sci Int 117:65–72.
18. Rajasekhar SSSN, TK Vasudha, Sex Determination by Biometry of Anterior Features of Human Hip Bones in South Indian Population. JCDR 2017; 11(6):13-16.

19. Steyn M, Işcan MY. Metric sex determination from the pelvis in modern Greeks. Forensic Sci Int. 2008;179(1):86.e1-6.
20. Thomas Manoj K, RD Walwante RD, Baig MM. Determination of sex from greater sciatic notch of hip bone: A cross sectional study at tertiary care hospital in Maharashtra. 2019;10(1):04-07.
21. Sridharan I, Muthusamy S, Thangarasu R, Krishnamoorthy S, Ganesan S. Morphometric Study of Acetabulum in Adult Dry Human Pelvic Bone. IndianJAnat.2019;8(4):289–292.
22. Sandhya K, Oraon S. A morphometric study of different parameters of greater sciatic notch in relation to sexual dimorphism in the jharkhand population. International Journal of Scientific Research.2019;8:646-647.