

## Identification of the sex of the individual from “Demarking Points” of hip bone

Kishor Dattatray Khushale<sup>1,\*</sup>, Yuvaraj Jayaprakash Bhosal<sup>2</sup>, K. Shyamkishore<sup>3</sup>

<sup>1,2,3</sup>Additional Professor, Seth GS Medical College & KEM Hospital, Parel, Mumbai

**\*Corresponding Author:**

**Kishor Dattatray Khushale**

Additional Professor, Seth GS Medical College & KEM Hospital, Parel, Mumbai

Email: kishorkhushale@ymail.com

### Abstract

**Introduction:** Identification of sex from the available bones has got tremendous value in the medicolegal cases. Anatomists are often asked for expert opinion regarding sex and age of the individual from the skeletal remains found under suspicious conditions. In this respect, metrical studies of the bones are more useful than mere physical examination. The growth factor and the nutrition of the man is widely variable in this world. Based on statistics, Demarking point (DP) are useful to identify the sex of the human clavicles with accuracy. Skeletal remains provide probably the most dependable information for identifying an unknown individual because of their relative durability with which they can be preserved and studied.

**Aims and Objectives:** The identification of an individual from his skeletal remains is of great medicolegal importance. The objective of the study was to evaluate the Demarking point (DP) from the hip bone. With this view, the present study has made an attempt to determine the sex of the hip bone from the Demarking point (DP).

**Material and Method:** One hundred and sixty adult hip bones (90 males and 70 females) of known sex were picked up at random from the skeletal collections of the department of Anatomy from various medical colleges in Mumbai. The following measurements were made from dry hip bones which did not show any fracture, pathology or wear and tear. Weight, length and width of the hip bone, length of pubis and length of ischium. Ischiopubic index and coxal index were calculated of each hip bone from the study sample. The instruments used are osteometric board, sliding caliper and ordinary weighing balance sensitive to 0.5 gm.

**Observation:** In this study it was found that ischiopubic index is the best criteria for discriminating sexual dimorphism in hip bones. Also the length of ischium is more useful for identifying male bones and length of pubis for female bones. Combination of these two i. e. the ischiopubic index was found to be the best discriminant parameters for both sexes.

**Result and Discussion:** Earlier workers have studied the actual range and means of certain parameters of bones for assigning sex. In present study seven parameters were studied for determining the sex from the hip bone. The Demarking points (DP) of various parameters if crossed by any hip bone, sex of that hip bone can be identified with certainty. However, it is not necessary for any bone to cross Demarking points (DP) of all parameters for identification of sex. Any single Demarking point (DP) for any of the parameters if crossed, would detect the sex with 100% accuracy.

**Conclusions:** The length of ischium was found to be more in male bones, length of pubis was found more in female bones and ischiopubic index was found to be the best criteria for determining sexual dimorphism in hip bones.

**Keywords:** Demarking point (DP), Identification point(IP), Coxal index, Ischiopubic index, Dimorphism.

### Introduction

The unknown bones are brought to the department of Anatomy to identify the sex in the medicolegal cases. Demarking Points (DP) is the best criteria to identify the sex of the individual from hip bone. With this study we can identify and confirm the sex from the hip bone.

Identification of sex from the available bones has got tremendous value in medicolegal cases. Anatomists are often asked for expert opinion regarding sex and age of the individual from the skeletal remains found under suspicious conditions. In this respect metrical studies of the bones are more useful than mere physical examination. Demarking point (DP) based on

statistics identify the sex of the human clavicles with accuracy<sup>[1]</sup>.

Skeletal remains provide probably the most dependable information for identifying an unknown individual because of their relative durability and accuracy with which they can be preserved and studied. The growth and the nutrition of the man are widely variable in this world therefore, although the skeleton of all the human species of the world have a common genetic feature, their measurement vary widely. Besides this, it also provides useful data for anthropological purpose and is of great medicolegal importance. The ischiopubic index was found to be the best discriminant parameters

for both sexes<sup>[2]</sup>.

Many osteologists tried to establish the sex by visual impression of the individual bones<sup>[3,4,5]</sup>. However the errors were about 23%<sup>[3]</sup> and 13%<sup>[4]</sup> in their studies. Objective assessment of the skeleton by metrical methods which provide precise and specific data are definitely superior to the traditional non metrical methods. These traditional non metrical methods essentially depend upon the subjective assessment of an individual which can go wrong. In the present study, an attempt has been made to evaluate the Demarking Point (DP) from the hip bone. On similar lines, an attempt has been made in the present study to identify the sex of the hip bone from Demarking points (DP).

### Aims and Objectives

The identification of an individual from his skeletal remains is of great medicolegal importance with this view, in the present study an attempt has been made to determine the sex of the individual from the Demarking point (DP) of the hip bone.

1. To measure weight (Fig. 1), length and width of the hip bone, length of pubis and ischium (Fig. 2, 3, 4, 5, & 6), ischiopubic index and coxal index of known sex.
2. The objective of the study was to evaluate the Demarking point (DP) from the hip bone.
3. To find the criteria for determination of the sex of the hip bone.

### Material and Method

One hundred and sixty adult hip bones 90 males and 70 females (Fig. 7, 8, 9, & 10) of known sex were picked up from the skeletal collections of the department of Anatomy from various medical colleges in Mumbai. Following measurements were made from dry hip bones which did not show any fracture, pathology or wear and tear. Instruments used are osteometric board, sliding caliper and ordinary weighing balance sensitive to 0.5 gm.

1. Weight: Bones are weighed on ordinary balance sensitive to 0.5 gm. (Fig. 1)
2. Length: (AB) Maximum distance between iliac crest and ischium measured on osteometric board. (Figure - 2 & 3)
3. Width (CD): Maximum distance between anterior and Posterior ends of iliac crest measured by osteometric board (Fig. 2 & 4)
4. Coxal index calculated as
 
$$\frac{\text{Width of hip bone}}{\text{Length of hip bone}} \times 100$$
5. Length of pubis: (OM) Maximum distance between the morphological centre of the acetabulum<sup>[6]</sup> and pubis measured with sliding caliper (Fig. 2 & 5)

6. Length of ischium: (ON)- Maximum distance between morphological centre of acetabulum and ischium measured with sliding caliper (Fig. 2 & 6)

7. Ischiopubic index calculated as

$$\frac{\text{Length of pubis}}{\text{Length of ischium}} \times 100$$

O is the central point of acetabulum usually marked by small notch representing the junction of ilium pubis and ischium<sup>[6,2]</sup>. Actual range, mean value, standard deviation (SD) of each parameter was recorded. Demarking Points (DP) were worked out from calculated ranges ( $\pm 3SD$ ) and the percentages of bones identified by these Demarking points (DP) for various parameters were noted<sup>[1]</sup>.

$x$ - is individual value ( $\bar{x}$  -Mean  $n$ - is No. of hip bones)

Standard deviation =

$$\sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

In the present study Identification point (IP)- maximum and minimum limit of the actual range of the measurement and Demarking point (DP) were worked out for the significant parameters and Percentage of the hip bone which could be "sexed" and calculated.

The limiting points of calculated range (Mean  $\pm 3SD$ ) as Demarking point (DP) for each measurement which covered the 99.75% of the samples. These Demarking points (DP) provides reasonable accuracy in identifying the sex of the hip bones.<sup>[1]</sup>



**Fig. 1: Ordinary weighing balance (sensitive to 0.5gm)**

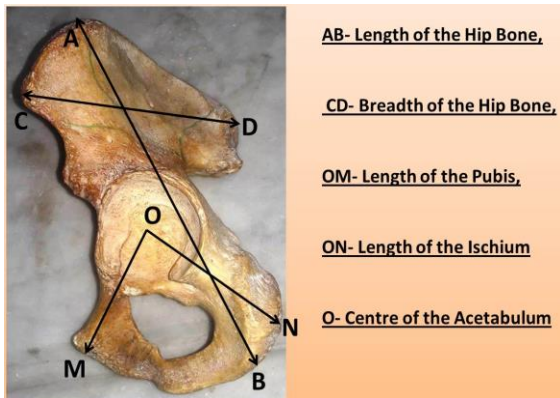


Fig. 2: Left hip bone measurements



Fig. 5: Length of pubis: (OM) maximum distance between the morphological centre of the acetabulum & pubis measured with sliding caliper



Fig. 3: Measurement of length of the hip bone (AB)



Fig. 6: Length of ischium: (ON) maximum distance between the morphological centre of the acetabulum & ischium measured with sliding caliper



Fig. 4: Measurement of breadth of the hip bone (CD)



Fig. 7: Male right hip bones (45)





**Fig. 8: Male left hip bones (45)**



**Fig. 10: Female right hip bones (35)**



**Fig. 9: Female left hip bones (35)**

### Observation

**Table 1: Measurement of the hip bone weight (gms) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Number	45	35	45	35
Mean	147.22	91.34	133.91	99.15
Actual range	120 - 198	70 - 152	110 - 165	83 - 128
Demarking point (DP)	> 152	< 120	>128	< 110
% beyond IP	53.21%	43.54%	56.32%	42.5%
Statistical significance = $p < 0.001$ (male vs. female)				

The weight of the bones of males and females were compared by student t- test. Male bones are significantly heavier (Table 1) than the female ones ( $p < 0.001$ ). The weight of male right hip bone varied from 120 to 198 gms with an average of  $147.22 \pm 28.11$  gms, while female bones weighed from 70 to 112 gms only had mean value  $91.34 \pm 18.18$ . No male right bone was less than 120 in this material and therefore any bone less than this weight could be classified as female one.

The 120 gms. weight serves as an Identification point (IP). Similarly the maximum weight of a female bone (152 gms) this serves as an Identification point (IP) for male bone. Bones heavier than this (152 gms) would only be male. However the bones weighing between 120 and 152 could not be "sexed". Such Identification point (IP) could assign sex to a large number of bones 53% male, 43.54% females (Table 1).

However, these Identification points (IP) could apply for 99.75 % of the cases from given sample. Provided these were limiting points of the calculated range i. e.  $\text{Mean} \pm S. D.$  Such limiting points are called as Demarking point (DP). Similar Demarking point (DP) worked out for the other parameters used in this study are shown in the table 2 to 8 and their comparative values.

**Table 2: Statistical calculations from measurement of weight (gms) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	120-198	70-152	110-165	83-128
Mean	147.22*	91.34	133.91*	99.15
Standard deviation	±28.11	±18.18	±15.32	±18.11
Calculated range	62.89-231.55	36.80-145.88	87.04-179.81	44.67-153.48
Demarking point (DP)	>145.88	< 62.89	>153.48	< 87.04
% beyond DP	30.66	-	41.66	

\*Statistical significance =  $p < 0.001$  (male vs. female)

As seen from Table 2 the percentage identified by Demarking point (DP) have been considerably reduced (31% Male) as compared to those sexed by Identification point (IP) (Table 1), as the range of overlap in case of Demarking point (DP) become much greater (62.89 in right male and 145.88 in right female hip bones). However, any right hip bone weighing more than 145.88 is bound to be a male one. Any right hip bone less than 62.89 is bound to be from female person. Demarking point (DP) for weight of hip bone thus can sort out 31% of right males bone and 42% of left ones though these Demarking point (DP) are of no value in identifying the female bones by weight alone.

**Table 3: Statistical calculations from measurement of length (mm) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	170-205	170-190	170-200	168-205
Mean	186.06*	181.32	187.20*	192.34
Standard deviation	±8.32	±14.35	±9.84	±8.15
Calculated range	161.10-211.02	138.27-224.37	157.68-218.89	108.09-216.45
Demarking point (DP)	-	< 161.10	>216.45	<157.68
% beyond DP	-	2.31	1.66	11.50

\*Statistical significance =  $p < 0.001$  (male vs. female)

The Demarking point (DP) for length of the male hip bone was found to be for the left side > 216.45 (Table 3)

The Demarking point (DP) for length of the female hip bone was found to be for right side < 161.10 and left side < 157.68 (Table 3)

**Table 4: Statistical calculations from measurement of width (mm) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	120-160	112-147	120.1-152	112-149
Mean	136.68*	129.50	136.20*	136.11
Standard deviation	±6.43	±7.22	±8.22	±9.96
Calculated range	117.39-155.97	107.84-151.16	111.34-160.66	106.23-165.99
Demarking point (DP)	>151.16	< 117.39	>165.99	<111.34
% beyond DP	1.33	3.2	-	7.1

\*Statistical significance =  $p < 0.001$  (male vs. female)

The Demarking point (DP) for width (mm) of the male hip bone was found to be for right side > 151.16 and left side > 165.99. (Table 4)

The Demarking point (DP) for width (mm) of the female hip bone was found to be for

right side < 117.89 and left side < 111.34. (Table 4)

**Table 5: Statistical calculations from measurement of coxal index of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	63.15-87.43	70.2-102.7	63.15-81.11	72-82.39
Mean	73.66	86.45	70.52	76.81*
Standard deviation	±3.17	±3.46	±2.87	±5.21
Calculated range	64.15-83.17	76.07-96.93	61.91-79.13	61.18-92.44
Demarking point (DP)	< 76.07	> 83.17	< 61.18	> 79.13

\*Statistical significance =  $p < 0.001$  (male vs. female)

The Demarking point (DP) for coxal index of the male hip bone was found to be for right side < 76.07 and left side < 61.18 (Table 5).

The Demarking Point (DP) for width of the female hip bone was found to be for the left side > 79.13 (Table 5).

**Table 6: Statistical calculations from measurement of the ischium length (mm) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	71-93	67-87	71-91	71-89
Mean	82.24*	76.42	80.48*	80.45
Standard deviation	±5.63	±6.84	±3.81	±4.61
Calculated range	65.35-99.13	61.56-96.94	69.05-91.91	66.62-90.28
Demarking point (DP)	> 96.94	< 65.35	> 90.28	< 69.05
% beyond DP	14.00	2.11	10	2.1

\*Statistical significance =  $p < 0.001$  (male vs. female)

The Demarking point (DP) for ischium length of the male hip bone was found to be for right side > 96.94 and left side > 90.28 (Table 6).

The Demarking point (DP) for width of the female hip bone was found to be for right side < 65.35 and left side < 69.05.

**Table 7: Statistical calculations from measurement of the pubis length (mm) of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	64-88	73-91	61-90	60-91
Mean	75*	82.13	75.64*	75.64
Standard deviation	±3.42	±4.16	±4.13	±4.15
Calculated range	64.74-85.26	68.3-95.96	63.25-86.03	63.19-88.09
Demarking point (DP)	< 68.3	> 86.26	< 63.19	> 86.03

\*Statistical significance =  $p < 0.001$  (male vs. female)

The Demarking point (DP) for pubis length of the male hip bone was found to be for right side < 68.3 and left side < 63.19 (Table 7).

The Demarking point (DP) for width of the female hip bone was found to be for right side > 86.26 and left side > 86.03 (Table 7).

**Table 8: Statistical calculations from ischiopubic index of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Numbers	45	35	45	35
Actual range	74.31-96.1	96.1-121	74.31-98.76	69.76-112
Mean	86.58*	108.55	86.53*	90.50
Standard deviation	±3.17	±7.12	±3.7	±4.23
Calculated range	77.5-96.09	87.19-129	82.83-97.63	77.81-103.19

Demarking point (DP)	< 87.19	> 96.09	< 77.81	> 97.63
% beyond DP	38	90	12	81.50
*Statistical significance = $p < 0.001$ (male vs. female)				

The Demarking point (DP) for ischiopubic index of the male hip bone was found to be for right side < 87.19 and left side < 77.81 (Table 8).

The Demarking point (DP) for width of the female hip bone was found to be for right side > 96.09 and left side > 97.63 (Table 8).

**Table 9: Percentage of the hip bones by Demarking point (DP) for various measurements of 160 hip bones**

Details of measurement	Right		Left	
	Male	Female	Male	Female
Weight	30.66	-	41.66	-
Length	-	2.31	1.66	11.50
Width	1.33	3.2	-	7.1
Coxal index	-	-	-	23.5
Ischium (length)	14.00	2.11	10	2.1
Pubis (length)	-	11.00	-	5
Ischiopubic index	38	90	12	81.50

## Discussion

A general rule is male bones are heavier and more massive than female bones. The crests, ridges, tuberosities and lines of muscles and ligament attachments are more strongly marked in males. These rules also govern the sizes of joints and articular surfaces as well. However the quantitative traits are receiving more and more attention in determination of sex<sup>[6]</sup>. Earlier workers have studied the actual range and means of certain parameters of male and female bones. Limiting points of these ranges have been taken as Identification point (IP) for assessing sex. Such Identification point (IP) some times can go wrong when applied to unknown cases. Demarking point (DP) based on statistically calculated ranges of various parameters of clavicles identify sex with 100% accuracy<sup>[1]</sup>.

Errors were found in determining the sex of the cranial bones by visual impression alone.<sup>[3,4]</sup> In larger population, the mean values of various parameters from different regions show significantly different values and therefore Demarking point (DP) have to be calculated separately for different regions. It is accepted that formulae applicable to one race may not apply to another race.<sup>[7]</sup>

Identification of the sex from the clavicle from length, weight and mid clavicular circumference have been measured in 368 clavicles and the measurable character of mid clavicular circumference has been found to distinguish as much as 72% from right and 48% from left clavicles<sup>[1]</sup>. Sexing of the humerus<sup>[9]</sup>, radius<sup>[10]</sup>, ulna<sup>[11]</sup>, fibula<sup>[12]</sup> and femur<sup>[13]</sup> were also studied. Sex of 184 adult human humeri of known sex (122 males and 62 females) were studied. Five parameters i. e. maximum width at

the upper end, circumference of the surgical neck, least shaft circumference, transverse diameter of the lower end and angle of humeral torsion were studied. They reveal that the maximum width of upper end of the humerus is the best criteria for identifying the sex of the humerus.<sup>[14]</sup>

In the present study, seven parameters were chosen for sexing the hip bone. The Demarking point (DP) of various parameters, if crossed by any hip bone, the sex of that hip bone can be identified with certainty. However, it is not necessary for any bone to cross Demarking point (DP) of all parameters for identification of sex. Any single Demarking point (DP) for any of the parameters, if crossed, would detect the sex with 100% accuracy. For example, in right male hip bone, the length of the ischium is more than 96.94 mm (Table 6) and it will have ischiopubic index less than 87.19 (Table 8).

It has been observed that for sexing hip bones, Demarking point (DP) of ischiopubic index was the best criteria for discriminating sexual dimorphism in hip bones (82% to 90% in females and 12% to 38% in males). The length of the ischium was more useful for identifying male bones (10% to 14%) and length for the pubis for female bones (5% to 11%)<sup>[15]</sup>. The observation in the present study is in accordance with the earlier authors.

## Conclusions

Male bones are significantly heavier (Table 1) than the female ones ( $p < 0.001$ ). The weight of male right hip bone varied from 120 to 198 gms with an average of  $147.22 \pm 28.11$  gms, while female bones weighed from 70 to 112 gms only had mean value  $91.34 \pm 18.18$ . No male right bone was less than 120 gms in this material and therefore any bone less than this weight

could be classified as female one. The 120 gms weight serving as Identification point (IP). Similarly the maximum weight of a female bone (152 gms) this serves as an Identification point (IP) for male bone. Bones heavier than this (152 gms) would only be male.<sup>[1]</sup>

The Ischiopubic index is best criteria for discriminating sexual dimorphism in hip bones (81.50% right hip bone and 90% left hip bone in females) (12% right hip bone to 38% left hip bone in males). Though the length of ischium was found to be more in male bones (10% to 14%) and length of pubis is more in female bones (5% to 11%). Combination of these two i.e. the ischiopubic index was found to be the best discriminating parameters for both sexes.<sup>[2]</sup>

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