Anatomy Journal of Africa, 2014; 3 (1): 294- 307

ORIGINAL COMMUNICATION

GENDER DIFFERENTIATION IN THE ADULT HUMAN SACRUM AND THE SUB-PUBIC ANGLE AMONG INDIGENES OF CROSS RIVER AND AKWA IBOM STATES OF NIGERIA USING RADIOGRAPHIC FILMS

Ubi Essien Isaac, Theresa Bassey Ekanem & Anozeng Oyono Igiri

Department of Human Anatomy, University of Calabar,P.M.B 1115 Calabar- Cross River State, Nigeria

ABSTRACT

A research study for sexing the sacra and sub-pubic angle of indigenes of Cross River and Akwa Ibom States was carried out using radiographic films of adults aged 18 -80 years. The aim of the study was to determine whether there is any difference in the measurements of the sacrum and pubic angle of males and females of Cross River and Akwa Ibom states origin; and to compare the findings with those obtained in other African population groups. The parameters that were assessed and measured included the length and width of the sacrum, the sacral index, and the sub-pubic angle. The measuring instruments used were a protractor for the sub-pubic angle and a ruler for the sacrum. The sex differences of the sacral length marked a greater mean in males but were not statistically significant (P>0.05) as it ranged from 92-126mm in males and 80-119mm in females. The sacral breadth marked a mean slightly higher in females than in males with insignificant statistical differences (P>0.05). It ranged from 99-134mm in males and 92-138mm in females. The sacral Index which was calculated as Width (maximum breadth) x 100 divided by maximum length was higher in females than in males with a significant statistical difference (P<0.05) ranging from 94.9 to 118.2mm and 97.6-124.4mm in male and female respectively. The sex difference of the sub-pubic angle was found to be statistically significant in females when male and female x-ray films were compared (P<0.05) with a range of 80-144º in males and 96-142º in females. The sacral index and sub-pubic angle are therefore useful parameters in sexing of the pelvic bone since they were found to be significant by statistical analysis.

Keywords: Gender, sacrum, pubic angle, radiograph, dimorphism

INTRODUCTION

Skeletal characteristics between male and female predict measurements for distinction between sexes. However Skeletal sex difference is usually quite

difficult to distinguish between male and female skeletons as there is a clear range of overlap between the sexes following measurements. The determination of sex in skeletons is only possible once the male or female have reached adolescence or adulthood. Studies by (Rupich 1996) reveal that Sexual dimorphism is slight in pre-adolescent children so this is a difficult task to perform if the skeleton is that of a child. A common way in which anthropologist might differentiate between male and female is to assess the characteristics of the bone structure. This of course is not always accurate but for the most part male bones are larger in size to female bones and are so because of the additional muscular strength that may build up, following the acquisition of secondary sexual characteristics at puberty, adolescence into adulthood.

Different attempts have been made in studying the characteristics of bones which could be helpful in gender differentiation. Good attempts were made by Ekanem et al. (2009), Aguado (2008), Oladipo et al. (2006), Igbigbi et al. (2000), Rupich (1996) , Flander (1978), , Ashley (1956), Parsons (1941), Fawcet (1938) and others. They studied bone features such as femur length, ischial length, pubic length, sternal width, and clavicle length. The study is of great medical importance as it enables one to determine or detect the specific structural features of the human body as well as knowing the sexual differences in the shape and structure.

Maples and Browning (1996) reveals posits that the study of bone characteristics can also be used to ascertain the biological and behavioural factors that affect the human skeleton since the skeleton is a dynamic system that undergoes growth and development throughout the individual's life span. Henche (2008) viewed that evaluation of total body bone mineral content (TBBM), Total bone mineral density (TBMD) and regional bone mineral content (BMC) is carried out in order to assess sex differences of bone in men and women. These studies suggest that total body bone mass peak acquisition takes place earlier in women than in men, leading to more reduced bone mass value, which in turn may be osteoporosis predisposing factor.

According to Stewart (1954), gender differentiation in human skeletal remains is an important component of different anthropological investigations and should be based on measurements and observations on the entire skeleton to be meaningful. Singh (1992) held that it is almost impossible to determine the sex of an individual from the skeletal remains unless all the bones are available, except in the case of the hip bones. However,

sex differences are visible in the skull, and in some other bones, but of all the bones, the pelvis is the greatest differentiator between the sexes. A female will have a larger sub-pubic angle to that of a man and this is obviously indicative of child bearing requirements in the female that are not required in the male species. This difference is noticeable across all species in nature where birth is from the womb. The male's sub-pubic angle or area is less than ninety degrees whilst the female's is more (Linda, 2003). Recently, there has been a new approach to the old problems of gender differentiation which is concerned with giving many different types of discriminate function techniques based on various measurements of the bone.

The sacrum has been chosen for measurement because although it is not found in archeological sites as are the oscoxae (hipbones) but as part of the pelvis will help to demonstrate sex differences which should be a standard for the purpose of identification. Since the sacrum is a component of axial skeleton and because of its contribution to the pelvic girdle and in turn to the functional differences in the region between the sexes, it has an applied importance in determining sex with the help of measurements carried upon it. Flander (1978) stated that attempts to test sex differences in the human sacrum systematically have been few and somewhat inclusive by current standards. The rule that the female sacrum is wider and flatter than that of the male permitting a greater outlet of the birth canal is however a rather subjective observation and should only be used in conjunction with other gender differentiation techniques.

The sub-pubic angle related to the pubic bones is one of the forensically important angle of the pelvic outlet found anteriorly below the symphysis pubis as a triangular interval between the inferior rami of the pubic bones. It is also referred to as the pubic arch (Keith and Dalley, 1999). It has been observed that the size of sub pubic angle determines the size of birth canal which is an important criterion in vaginal delivery. The sub-pubic angle is more angular in male being 50 to 60 degrees and in female more rounded, usually 80-85 degrees depending on the race and ethnic groups (Harold, 1974).

In a recent study of indices of Malawian subjects by Igbigbi and Nsamati (2000), sex could be accurately assigned to 87.8% for males and 100% females using x-ray films; and 92.3% males and 100% females using skeletal bones. The sub-pubic angle is expected to be a useful sex determinant due to its dependency on the growth of the pubic bones. However, sex differences in the

sub-pubic angle have been found to be significant both in the adult and foetus (Boucher, 1957; Giles and Eliot, 1993; Igbigbi and Msamati, 2003; Oladipo, 2006).

MATERIALS AND METHODS

The study was conducted to document the sacral and sub-pubic angle measurements of Cross River and Akwa Ibom States Indigenes and compare results for possible differences. One hundred x-rays films were collected from the Radiography Department of the University of Calabar Teaching Hospital, University of Uyo Teaching Hospital, the General Hospital, Calabar and the Nigerian Navy Hospital, Calabar and used for this study. Films used were free from pathological disorders or any fracture involving the pelvis or the sacrum. Other materials that were used in the measurements included an x-ray viewing box, a pencil, a protractor and a ruler.

The identification of films was on the basis of sex, age and place of origin. The films were taken with routine distance of 92cm in the anterior posterior view. The x-ray films showed the complete pelvis and out of the 100, 50 were males and 50 were females of ages ranging from 18 – 80 years.

The method used for this findings was Wilder (1920), Davivong (1963) and Flander (1978) except otherwise stated. Measurements in millimeter (mm) were taken using a ruler and pencil (where necessary) with the films placed on a viewing box.

The following parameters were examined and measured:

1. Maximum length or Wilder's mid-ventral straight length. This is the distance between the sacral promontory and the junction of the sacrum and coccyx.
2. Maximum breadth or Wilder's anterior straight length. This is the distance between the alae of sacrum.

The sacral index was calculated as Maximum breadth x 100/Maximum length

The hundred sacra that were measured all possessed 5 sacral segments and did not show any form of developmental anomaly or disorder

3. The sub-pubic angle was measured form radiographic films that had the pelvis placed such that the ischial tuberosity and the inferior end of the coccyx were resting on a horizontal surface. The lower border of the inferior rami of the pubis had straight medial borders and these were considered to be the sides of the angle. The angle was

measured by placing each radiograph on an x-ray viewing box for clear visualization. A point was chosen at the inferior midline of inter-pubic disc and two tangential lines drawn at the inferior border of the pubic rami intersecting at an angle of the chosen point. A protractor was placed over the intersection of these two lines and the angle measured. The statistical method used to analyze the data on the measured parameters was the one way analysis of variance. The sex differences between males and females was determined using T-test and ($p<0.05$) was taken as being statistically significant.

RESULTS

THE MAXIMUM LENGTH OF THE SACRUM:

The mean length of the sacrum was greater in male than in females though the differences were not statically significant ($p> 0.05$). It varied from 92mm – 126mm with a mean value of 109.2mm ± 7.7 in males and 80mm – 119mm with a mean value of 103.5mm ± 9.8 in females. The identification points were 119mm for male and 92mm for females.

The demarking points based on the limiting points of the calculated range (mean ± 3 S.D) gave >132.9 for males and <86.1 for females. The demarking point which is the low or high values deduced from the calculated range, obtained by using the formula mean ±3 standard deviation is more useful in sex determination. The identification point is the low or high value got from the actual range of the values measured from male and female pelvis.

Table 1: Measurements in (mm) and statistical Analysis of the Length in 100 sacra (50 males and 50 females)

Details of measurements	Male	Female
Number	50	50
Mean value	109. 2mm	103.5mm
Actual Range	92- 126	80- 119
Standard deviation (SD)	7.7	9.8
Identification point (IP)	>119	< 92
Calculated range	86.1- 132.3	741.1- 132.9

Demarking point (DP)	> 132.9	< 86.1

p>0.05 (male v female)

Table 2: Measurements in (mm) and statistical Analysis of the maximum breadth in 100 sacra (50 males and 50 females)

Details of measurements	Male	Female
Number	50	50
Mean	115.9mm	116.3mm
Actual range	99- 134	92- 138
Standard deviation (SD)	6.8	8.1
Identification point (IP)	<92	>134
Calculated range	95.5- 136.3	92.0- 140.6
Demarking point (DP)	<92.0	> 136.3

p>0.05 (male v female)

Table 3: Measurements in (mm) and statistical Analysis of the Sacral Index in 100 sacra (50 males and 50 Females)

Details of measurements	Male	Female
Number	50	50
Mean	106.3	112.2
Actual range	94.9- 118mm	97.6- 125mm
Standard deviation (SD)	5.8	7.2
Identification point (IP)	>125	<94.9
Calculated range	88.9- 124	90.4- 137
Demarking point	<90.4	>123.7

P<0.05 (Male v female)

Table 4: Measurements in degree and statistical Analysis of the sub-pubic angle in 100 pelves (50 males and 50 females)

Details of measurement	Male	Female
Number	50	50
Mean	94.2^0	117.1^0
Actual range	80- 114	96- 142
Standard deviation (SD)	7.4	11.3
Identification point (IP)	<96	>114

Calculated range	72.0- 116.4	83.1- 151.0
Demarking point (DP)	< 83.1	> 116.4

P<0.05 (male v female)

Table 5: Comparative analysis of the ranges mean and the demarking points of the sub-pubic angle of different population groups

Sub-pubic angle(^{0})	Range (^{0})	Mean ±S.D	Mean±2S.D	Demarking Point	**Authors**
Malawians					**Igbigbi, 2000**
Male (n=75)	66-150	99.6±15.73	67.71±130.62	<99.95	
Female(n=48)	86.174	129±14.19	99.95±158.19	>130.62	
Ugandans					**Igbigbi, 2003**
Males (n=75)	50-140	93.86±21.1	51.52±136.1	<80.53	
Female(n=48)	75-155	116.11±17.79	80.53±151.69	>136.10	
Nigerians					**Oladipo, 2006**
Male(n=99)	74.123	109.38±10.00	98.38±129.38	<92.33	
Female(n=10)	90-146	119.48±12.06	95.36±143.6	>113.07	
Ijaws					**Oladipo, 2009**
Male(n=38)	91.123	109.38±10.00	98.38±129.38	<95.36	
Female(=62)	100-146	119.48±12.06	95.36±143.6	>129.38	
Igbos					**Oladipo, 2009**
Male (n=62)	74-111	95.29±10.58	75.96±116.04	<85.74	
Female(n=55)	90-140	111.44±12.85	85.74±137.14	>116.64	
Present study					**Isaac et al, 2010**
Male(50)	80-114	94.2±7.4	72.0±116.4	<83.1	
Female(50)	96-142	117.1±11.3	83.1±151.0	>116.42	

THE MAXIMUM BREADTH OF THE SACRUM

The mean value of the breadth in females was larger than in males with no statistical significant differences ($p>0.05$). The range was 99mm – 134mm with a mean value of 115.9mm ± 6.8 in males and 92mm – 136mm with a mean value of 116.3mm ± 8.1 in the females. The identification points were 134mm for females and 92mm for males. The demarking point of >136.3 female and <92.0 male was deduced.

THE SACRAL INDEX

The mean value of the sacral index (S.I) was higher in females than in males with a significant statistical difference ($p<0.05$) with the values varying from 94.9- 118.2mm and a mean value of 106.3 ± 5.8 in males; and 97.6- 125mm variance with a mean value of 112.2 ±7.2 in females. The identification points of >125 and <94.9 were deduced in males and females respectively whereas the demarking points of < 90.4 in males and >123.7 were obtained.

THE SUB-PUBIC ANGLE

The sub-pubic angle had a greater mean value in females than in males with significant statistical differences ($p<0.05$). The range varied from 80-114º in males with a mean value 94.2^0 ± 7.4 in males and 96^0 – 142^0 in females with a mean value of 117.1^0 ± 11.3. The identification point was <96 for males and >114 for females and 50% of the female sub-pubic angle were identified and none was identified in the male. Demarking points of <83.1 and >116.4 were developed for males and females respectively though none of the angles were sexed.

DISCUSSION

Physical anthropological studies provide a direct method of assessment (providing evidence) when skeletal populations of different sexes and races become available. Sexual dimorphism is a vital tool for identifying and differentiating gender. The morphology or shape of the pelvis differs between males and females. These differences can be recorded by noting the presence of the features associated with a particular sex, or by measuring the pelvis and using statistical analysis to estimate sex. Anatomist understands that the sex differences in the human pelvis as a whole are related to differences in function and are trained to recognize the physical differences associated with function.

Anatomist who have studied sex differences in the sacrum including Flander (1978), Stewart (1979) agree

that certain parameters in the sacrum can be used to identify and differentiate gender of an individual while Wright (1984), Giles (1993), Maples (1994), Igbigbi et al (2000), Oladipo et al (2006) have found the sub-pubic angle to be a reliable parameter for determining sex both in adults and fetuses.

In this research, gender differentiation in the sacrum were metrically examined in detail and it showed that the standard deviation (SD) is extremely high in most parameters and indices but the means of the sexes were significantly differentiated in those parameters that were assessed. The parameters which proved to be most significant ($p<0.05$) for expressing differences in sex is the sacral index and the sub-pubic angle. These results agree with those of Stewart (1979), and Flander (1978). Nevertheless, the differences in sex such as length, breadth and transverse diameter of the body of first sacral vertebra were not significant ($p>0.05$) in determining gender differences. All the sacra that were assessed had five segments and the possible reason for this is that the diet of the people promotes bone growth of these features.

In this study, the sacral index (S.1) due to its statistical significance is obviously the most important criterion for determining the sex of the sacrum . Analysis of the sex differences in the sub-pubic angle showed that it was statistically significant ($p<0.05$) agreeing with the results of Boucher (1957), Wright et al (1984), Giles (1993), Maples(1994) Igbigbi et al(2003) and Oladipo et al(2009), that gender differences exist in the male and female sub-pubic angle.

From the results, the proposed explanation based on evidence that observed sex differences in the sacrum are statistically significant ($p<0.05$) have been affirmed. Though the demarking points based on the calculated range marked sex in a lesser number of the sample group compared with the identification points which are merely the upper and lower limits of the normal range in a given data. However the demarking point is preferred because of the 100 percent applicability to 99.75% of the population in the sub-pubic region as compared with the identification point which is applicable only to that data (Singh et al, 1973).

The need for demarking points arises because different races have different body size, stature and hence bone size. The following factors explain why different races have different demarking points. They include: age, height, weight, nutrition, heredity, climate, race, disease and sex.

.

AGE

Assessing age in the adult skeleton presents a special challenge because any part that were going to fuse as a part of maturation have done so. It is extremely difficult to estimate sex for pre-pubertal remains because the characteristics of the skeleton that indicates sex do not appear until after puberty. Adults have bigger bones with fused epiphysis thus the mean value of measurements taken will be greater in adult than in children.

HEIGHT

Holland et al (1981) stated that there is a general association between height and pelvic size, namely that the taller an individual, the larger the pelvic size. Thus races made up of predominantly tall people will have different demarking points from races made up of short people (Stewart, 1954).

WEIGHT

The weight of people depend on the mass of bones and people with heavy bones have bigger bones hence a population of weighty or bulky people have a different demarking point from population of less weighty people. A significant correlation observed between total body bone and mineral content (TBBM), and sex suggest that total bone mass peak acquisition takes place earlier in women than in men, leading to more reduced bone mass value which in turn may be osteoporosis predisposing factor. It is well known that men suffer from osteoporosis to a lesser degree than women. This fact has been related to the marked bone mass loss observed in female after menopause (Henche, 2008).

NUTRITION

Bone growth is stimulated by ions like calcium, potassium, phosphorus which are mostly found in river areas. The people of Akwa Ibom and Cross River States are richly blessed with rivers and have diets that contain bone growth stimulating nutrients. Vitamin D from sunlight, which is needed for bone growth, is also found in these two states. These factors explain why bones found in these areas do not have anomalies of the sacrum and these factors will cause a demarking point different from areas where people lack diets which stimulate bone growth.

HEREDITY

It was viewed by Singh and Singh (1972) that heredity including racial or group heredity may likely function as a primary factor within which function operates as

a secondary factor. Heredity is transmitted through genes and a population which had bulky ancestors will have bulky descendants, this will cause the demarking points for this area to be different from that of less bulky people.

CLIMATE

Climate affects demarking points as can be seen in the Eskimos. Those living in a cold or damp area will have stunted growth while those in hot region are taller since height is associated with pelvic size there is bound to be a difference in demarking points.

RACE

Giles (1993) states that race differences are known to reduce accuracy of sex determination. Therefore as race differences exist, different demarking points also exist. This is in line with the results deduced by various authors such as Tague(1989) who measured the sub-pubic angle of Amerindians, white Americans and Black Americans, Caldwell and Moloy (1933) who studied the sub-pubic angle of Caucasians with a mean of <60 for males and <90 for females; Igbibi and Msamati (2000) who measured the sub-public angle of Malawians obtaining a mean of 92.2 for males and 129.1 for females, and Ugandans with a mean of 93.86 for males and 116.11 for females; Oladipo, (2006) studied the angle in Nigerians and obtained a mean value of 91.87 for males and 115.4 for females.

The demarking points of the sub-pubic angle in different races have been determined. Malawians marked <99.95 and 130.62 in males and females respectively; Ugandans marked <80.53 and >136.10 in males and females respectively; Nigerians had a demarking point of <92.33 for males and >113.07 for females (Table 4).

In the case of racial differences in the sacrum Flander's study was useful because she had developed a technique to assess sexes and races simultaneously by using sacra from American Blacks and White (50 each sex / race). Two discriminant functions were developed by her. The first one assumed that race was known. The accuracy of determination based on a total of six measurements ranged from an average of 84% for white to 90% for Blacks. In the second function, she had assumed race to be unknown. Classification accuracy ranged from 54% to 74%.

DISEASE

Potential causes of variability in demarking points of various races are degenerative disease such osteoarthritis or osteoporosis and nutritional deficiency disease such as rickets or osteomalacia which are known to cause deterioration

and distortion in vertebral column and pelvis.

SEX

In relation to gender differences, Rupich (1996) stated as a general rule that male bones are more massive and heavier than female bones. The crest, ridges, tuberosities, lines of muscle and ligament attachments are more strongly marked in the males. He further stated that in the case of the pelvic girdle, additional sex differentiating features such as sacral index, ischiopubic index sub pubic angle are added. These extra features are due to the different productive functions mainly influenced by sex hormones.

CONCLUSION

The female pelvis differs from the male pelvis in being designated to pass a large headed infant through a narrow space. The sacrum and sub-pubic angles of 50 males and 50 females of Akwa Ibom and Cross River States origin were assessed and measured. The purpose of this study was to identify gender by measuring parameters which include maximum length, maximum breadth, sacral index and sub-pubic angle. The demarking points for gender differentiation was calculated for Akwa Ibom and Cross River States of Nigeria for different parameters of the sacrum and also for the sub-pubic angle. From the classification of sacra according to the Sacral index both the male and female sacra from the people of Cross River and Akwa Ibom States fall into the platyhieric class (wide sacrum). With the exception of the sacral index and sub-pubic angle, all other measurements and indices taken in this work were not significant ($p>0.05$). Sex determination in the sacrum alone is not satisfactory due to the overlap of the male and female values. However, the sub-pubic angle was of more use in sex or gender differentiation as the overlap occurred in few cases.

REFERENCES

1. Aguado HS. 2008. Total and regional bone mineral content in healthy Spanish objects. Internet J. Biol Anthropol 4: 56-61
2. Ashley GT. 1986. Human sternum influence of sex and age of its measurement: Am J Forensic Med 3: 27-43

3. Bennett K. 1987. A field Guide for Human Skeletal Identification Springfield (16): cc Thomas, 2:14-16
4. Boucher BJ. 1977. Sex differences in the fetal pelvis. Am J Phys Anthropol 4: 581-600
5. Brothewell D R. 1981. Digging up bones: The excavation treatment and study of human skeletal remains. 3rd ed. Itheca (NY), Cornell Press. 7:86-90
6. Cosmas J. 1960. Manual of Physical Anthropology. Revised and enlarged English ed. Charles C. Thomas Springfield Illinois, USA. 5:33-36
7. Davivongs V. 1973. The Pelvic Girdle of the Australian Aborgine; Sex difference and Sex determination. Am J of Phys Anthropol 21:443-445
8. Ekanem TB et al. 2009. Radiographic determination of sex differences in ischiopubic index of a Nigerian population. Internet J Biol Anthropolol. Vol.3 no 3
9. Flander LB. 1980. Univariate and Multivariate Method for sexing the sacrum. Am J Phys Anthropol 49: 103-110
10. Giles E & Eliot O. 1978. A new method for assessing the sex of fragmentary remains: femoral shaft circumference. Am J Phys Anthropol. Vol.48, issue 2, 227-31
11. Gafni RL & Baron J. 2004. Sexual dimorphism in the pelvis. J of Paed. Elsevier, 13: 232-235
12. Hamilton J et al. 1975. Anatomy of the Human Body 2nd ed. London: Faber and Faber. 2: 26-29
13. Hilson S. 1992. Mammal bone and teeth: An introductory guide to methods of identification. London Institute of Archaeology; University College, 2: 16-25
14. Holland EL et al. 1981. Associations between pelvic Anatomy: Height and year of birth of men and women in Belfish. J Hum Biol 9: 113-120
15. Igbigbi PS & Msamati BC. 2000. Ischiopubic index in Black Malawians. East Afr med J 77(9): 514-516
16. Igbigbi PS & Nanono AM. 2003. Determination of sex and race from the sub-pubic angle in Ugandans. Am J Forensic Med Pathol 24(2):168-171
17. Inuwa I. 1992. A study of the shaft of the neck of the femur and sub-pubic angle in Hausa tribe of Nigeria. West Afr J Anat 1(2):64
18. Iscan MV, Loth SR & Wright RK. 1984. The characteristics of sex in the skeleton. J Anat sci 7: 34-39
19. Krogman WM. 1949. The human skeleton in Forensic Medicine. Springfield Illinois, USA; Charles C. Thoreas, 16:154-167
20. Moore K & Dalley A. 1999. Clinically Oriented Anatomy. 4th ed.,
21. Lippincott Williams and Wilkins: pp 332-331

22. Lima F et al. 2001. Effect of Impact load and active load on bone metabolism and body composition of adolescent athletes. Med Sci Sport exerc 33(8): 1318-23.
23. Linda LK. 1990. Fundamentals of Forensic Anthropology. Hobeken USA: John Wiley & Sons Inc, 6:76-79
24. Maples WR & Browning M.1994. The importance of studying bone characteristics. J Forensic Sci 6:73-74
25. Marielle JH & Summeren V. 2008. The association of vitamin K with childhood bone mineral content. British J Nutri 14: 96-99
26. Oladipo GS et al. 2009. Comparative study of the sub-pubic angles of adult Ijaws and Igbos. Asian J of med Sci 1(2):26-29
27. Patel M et al. 2005. Sexing of sacrum by sacral index and Kimura's base-wing index. Internet J Anat & Forensic Med 27(1):5-8
28. Rupich RC. 1996. Gender and Race differences in bone mass during Infancy. J Hum Biol 12: 56- 58

29. Schoenau CM et al. 2002. Journal of bone and Mineral Content American Society of Bone mineral Resourses. 4:22-24
30. Singh I. 2002. Essentials of Anatomy. New Delhi India: Jaypee Brothers Medical Publishers (Ltd): 2: 90, 244
31. Singh S & Gangrade KC. 1968. The Sexing of Adult Clavicles, demarking points for Varanasi zone. J Anat Soc India 7: 20-30
32. Singh S. et al. 1972. Identification of sex from skeletal remains. Bull
33. Inst. of Medical Sciences; 3: 65-75
34. Stewart TD. 1974. Essentials of Forensic Anthropology. Springfield Illionois USA: Charles C Thomas publisher, p23-28
35. Stewart TD. 1948. Medicolegal aspects of skeleton I: Sex, race and stature. Am J Physical Anthropolol 6: 315-321
36. Wilder H. 1920. A Laboratory Manual of Anthropometry. Philadelphia: Blackstone & son co; 2 (16)
37. Washburn SL. 1948. Sex Differences in the Public bone. Am J Phys Anthropol. 6:199-206