Osteometric Studies on Human Femurs

T.Jayachandra Pillai[1], C.K.lakshmi Devi[2], T.Sobha Devi[3]

[1]Proffessor, Dept of Anatomy, S.V. Medical College, Tirupati NTRUHS India.
[2]Associate proffessor, Dept of Anatomy, S.V. Medical College, Tirupati NTRUHS India.
[3]Assistant proffessor, Dept of Anatomy, S.V. Medical College, Tirupati NTRUHS India.

Abstract:*It is commonly accepted that the examination and statistical analysis of femoral Anthropometry among different populations reveals a great amount of variation due to the face that the femoral Anthropometry measurements from different countries are likely to be affected by racial variations in diet, heredity, climate and other geographical factors related to life. Anatomists have carried out various measurements to differentiate sex of the femora. This was done in femora of either known or unknown sex. Various parameters were used by Anatomists for measuring femora. 50 dry human femora of unknown sex were collected from different medical institution and Anthropology department of S. V. University, Tirupati. By eliminating pathologicaly misfit femora, 50 femora in good condition were selected. Each femur was carefully measured for 6 parameters which are already described in materials and methods. 1.Maximum length of femur,2.Vertical diameter of head,3.Epicondylar breadth,4.Neck-shaft angle,5.Transverse diameter of head,6.AP diameter of shaft – Upper,middle, lower.The measurements were statistically analyzed and tabulated. The present study reveals that femora of unknown gender can be sexed to the extend of 75-80% by three parameters namely, Vertical diameter of head, Neck-shaft angle and Transverse diameter of head.*
Key words:*Femur, Maximum length of femur,Vertical diameter of head,Epicondylarbreadth,Neck-shaft angle,Transverse diameter of head,AP diameter of shaft*

I. Introduction

Skeleton is playing important role in various sciences like medicine, forensic sciences, Anthropology etc., Estimation of sex, age, race, stature by skeleton and the presence of disease is discovered by Krogman and Iscan(Ref.7) (1986). They stated that record of organic evolution is largely written by the hard parts of the body recognizable even after many years of death. Sex is determined after death by skeletal remains of that individual by some Forensic Anthropologists with the help of pelvis, skull. It is some what easier to identify the sex of individual. Here in the present study we are taking the long bones (Femur) either individually or in combination, have been subjected to statistical and morphological analysis for the purpose of determination of sex.

Studies on Femur has been reported on various populations and there are many variations in size in different populations and Germans (Mall et al.2000, Ref.9).It is commonly accepted that the examination and statistical analysis of femoral Anthropometry among different populations reveals a great amount of variation due to the face that the femoral Anthropometry measurements from different countries are likely to be affected by racial variations in diet, heredity, climate and other geographical factors related to life style.Anatomists have carried out various measurements to differentiate sex of the femora. This was done in femora of either known or unknown sex. Various parameters were used by Anatomists for measuring femora.

The femur is ossified from one primary centre for the shaft, 3 secondary centre for upper end, one each for head, greater trochanter and lesser trochanter and one secondary centre for lower end.The primary centre appears in the middle of the shaft at about 7th week of intrauterine life. The centre for the head appears at about 6th month to 1 year after birth, that for the greater trochanter about 4th year, and for lesser trochanter at about 14th year. The lesser trochanter unites with diaphysis during 16th year, the greater trochanter unites with diaphysis during 16the year, the greater trochanter at 17th year and the head at about 18th year. The neck is derived from the primary centre as a extension of shaft. The epiphyseal plate between the head and neck is initially horizontal and becomes oblique by the age of 8 to 12 years. Therefore, the lower end is growing end of femur.The head and lower end are pressure epiphyses, where as the greater and lesser trochanters are traction epiphyses.

II. Materials & Methods

Material:

The material used for the study contained 50 human femora of unkown sex obtained from different medical institutions and Anthropology department of S. V. University, Tirupati town and from the departmental pool. The bones collected are free from any pathological lesions or fractures and are in good condition. The bones collected roughly belong to the age group of 18 to 60 years.

Instruments Used:
1. metal sliding caliper
2. Osteometric Board

Method of Study
The following parameters were taken into consideration and measured on femur in order to determine the sex.
1. Maximum length
2. Vertical diameter of head
3. Epi-condylar breadth
4. Neck-shaft angle
5. Transverse diameter of head
6. AP diameter of shaft – Upper,Middle,Lower

1. Maximum Length: It measures the straight distance between the highest point of the head and the deepest point on the medial condyle(Fig.1).
2. Vertical diameter of Head: It measures the straight distance between the highest and deepest points of the head(Fig.2).
3. EpicondylarBreadth: It measures the distance between the most projected points on the epicondyles(Fig.3).
**Procedure:** Place the bone in such a manner on the osteometric board with its posterior surface downwards, that one of the epicondyles touches the vertical long wall while the movable cross piece touches the other lateral condyle.
4. Neck-Shaft Angle: It is the angle made by axis of shaft with the axis of the upper anterior collum. Axis of collum is determined by means of a thread which divides the anterior surface of tecollum in two equal halves. Axis of the Shaft is determined by a thread which extends in the mid sagittal plane over the anterior surface of the bone from the upper end of the oblique line of the ondyles. In case of strongly developed torsion, it may be difficult to fix a thread on the entire surface; so take only the axis of the upper shaft into consideration for such cases(Fig.4).
Materials: Thread, mud clay
5. Transverse diameter of head: It measures the straight distance between the most laterally projected points on the equatorial plane taken at right angle to the vertical diameter(Fig.5).
6. Antero-posterior diameter of shaft:Upper : It measures the antero-posterior diameter of the upper shaft taken at right angle to the transverse diameter of shaft.**Middle :** It measures the distance between the anterior and posterior surfaces of the bone approximately at the middle of the shaft ie., the highest elevation of the lineaaspera.**Lower :** It measures the minimum distance between the anterior-posterior margins of the lower part of the shaft, approximately 4 cm above the cartilaginous margin of the condyles taken in the mid sagittal plane.
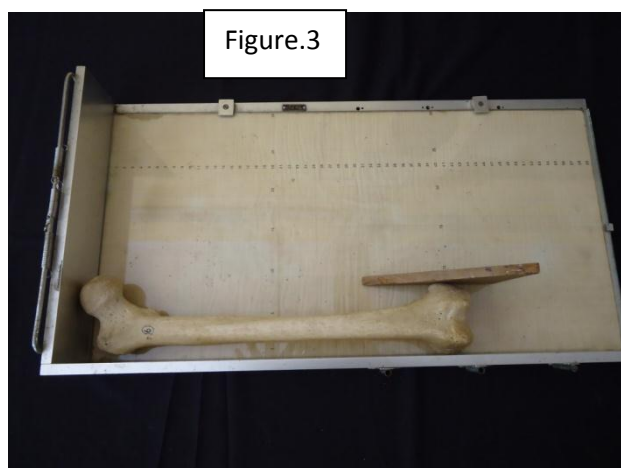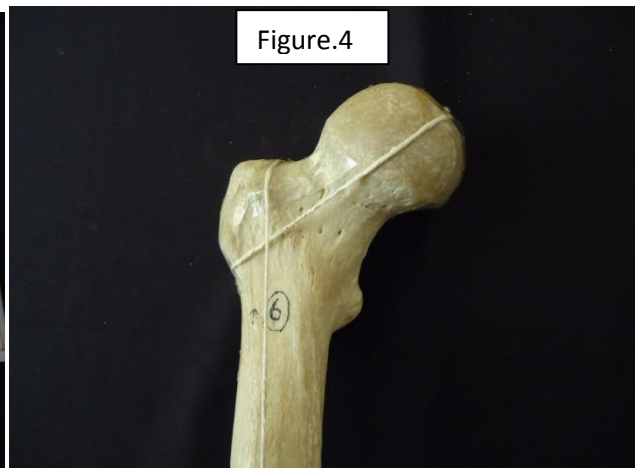

Figure.1   Figure.2
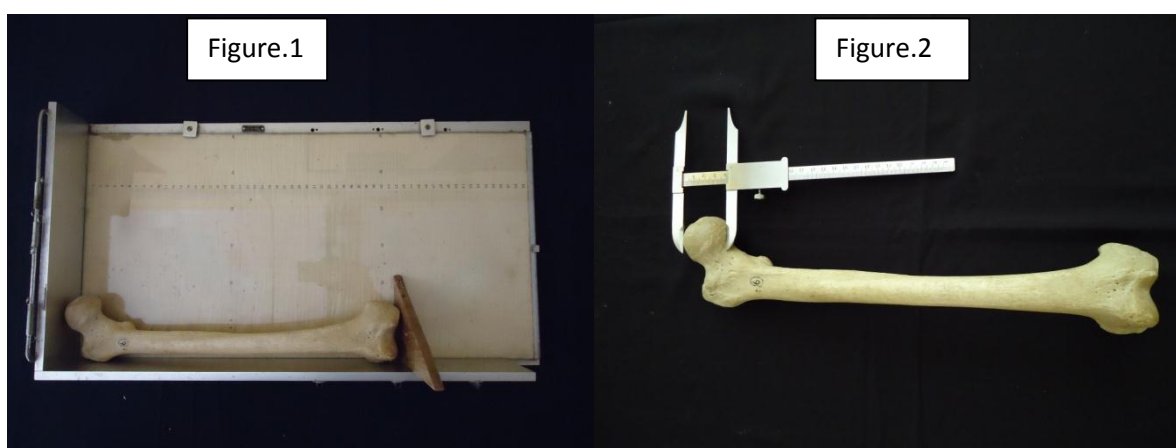
Figure.3

Figure.4

III. Results And Discussion

50 dry human femora of unknown sex were collected from different medical institutions and Anthropology department of S.V. University, Tirupati. By eliminating pathologically misfit femora, 50 femora in good condition were selected. Each femur was carefully measured for 6 parameters which were already described in materials and methods. The data thus obtained is tabulated (table – 1). An attempt is made to identify the femora of either sex by measuring various parameters and by comparing the data with the available previous values.

The maximum length of the femur varies from a minimum of 373 mm to maximum of 514 mm with a mean value of 437.4mm (table 2). When this is compared to the range of the known sex, 42 femora out 50 could be identified as belonging to male and 8 to female (table 5). Maximum length of femur has been reported earlier (Leelavathy N, et al. 2000, Ref.8). Comparisons were drawn separately for male left and right femora as well as for female left and right femora, because individuals tend to favour one limb over other. It also has been observed that the female femur is shorter than male and in male the left longer than right and vice versa in female. Maximum length of femur" was the best parameter for sexing the unknown femora (Leelavathy et al.2000,Ref.8). . Discriminant analysis confirmed that the male femur is usually larger than the female femur (Alan M. W Porter 1994,Ref.1) sex differences in long bones is that typically male bones are longer and more massive than typically female bones (krogman 55,Ref.16). In my present study there is wide variation of this particular parameter.

Vertical diameter of head of femur ranges from a minimum 34mm to maximum 51mm with a mean value of 42.24mm (table 2). When compared to the range of known sex, 23 out of 50 identified as belonging to male and 27 to female (table 5). This is in correlation with the present observation and this parameter is giving higher percentage of accuracy in sexing the femur.The mean head diameter of male femur was significantly greater than the mean head diameter of female femur (S.A Asala 2000,Ref.1). "Max-head diameter alone could correctly assign sex to 92.5% of males and 95.5% females" (Rumapurkait 2004,Ref.11). Head vertical diameter of Right femur was significantly greater than Left femur.

In 1913-14 and 1914-15, Parsons suggested width of lower end as sex category and stated that >72mm is male and <71mm is female, 71-72mm is male or female. Neck-shaft angle ranges from a minimum of 106^0 to maxium of 135^0 with a mean value of 125.30^0 (table 2) when this was compared with the range of known sex 24 femora out of 50 could be identified as belonging to male and 26 to female. This is in correlation with the present observation and this parameter is giving higher % of accuracy (table 5) in sexing of the femur. Neck-shaft angle has been reported earlier (W. Henry Hollinshead 1966,Ref.5,6) with an average of 126^0. The neck shaft angle ranges from $120^0 – 136^0$ with a mean of 126.7^0. Any estimated defective angle can be of help for forensic identification of an individual with pathological changes leading to an abnormal gait . Some authors reported that angle is bigger in female Krogman(55,Ref.7). Some authors reported that angle is bigger in males (Henry gray,Ref.3), , RumaPurkait (1996,Ref.11,12); Henry Hollinshead (1966,Ref.5,6) with 126^0 average. , W.T. Hamilton (1976,Ref.4), Gray's text book of Anatomy gives 125^0 average, Tanerziylan (2002,Ref.14). The results of neck shaft angle of left femur were generally shown to have greater value, but they were not significantly greater than the corresponding dimensions of right femur (Tanerziylan 2002,Ref.14).

Transverse diameter of head of femur varies from a minimum 28mm to maximum 44mm with a mean value of 37.86mm (table 2). When compared to the range of known sex, 22 femora out of 50 identified as belonging to male and 28 to female (table 5). Transverse diameter of head of femur has been reported earlier. (RumaPurkait 1996,Ref.10). This is not in correlation with the present observation. In the present study (table 3).TanerZiylan (2002,Ref.14) reported that there is no significant difference between Rt and Lt femora (Rt=44.7, Lt =44.3).

Thee is enormous sexual difference in male and female head of femur, the results are of great applied and practical value in referred specimen in medicolegal field (RumaPurkait 1996,Ref.10). In male femur, mean transverse diameter is 86.29mm and in female femur, mean transverse diameter is 74.45mm. this study of diameter of head of femur independently could be used for determining the sex of head of femur with high significant results.

Anteroposterior diameter of femoral shaft, in the present study we had taken measurements of femoral shaft at three different sites, Upper-just below the lesser trochanter, Middle – approximately at the middle of shaft, ie. Highest elevation of lineaaspera. It measures the distance between anterior and posterior surfaces of the bone. Lower – approximately 4 cm above the cartilaginous margin of condyles taken in mid sagittal plane. Upper anteroposterior diameter of femur ranges from minimum of 22mm to maximum of 32 mm with a mean value of 26.56mm. Middle anteroposterior diameter of femur varies from minimum of 22mm to maximum of 30mm with a mean value of 26.38mm. Lower anteroposterior diameter of femur ranges from minimum of 24mm to maximum of 35mm with a mean value of 28.50mm (table 5). When this is compared to the range of known sex 47 out of 50 femora could be identified as belonging to male and 5 to female by using middle APD. 50 out of 50 could be identified as belonging to male only by using lower APD (table 5). Antero posterior diameter of femoral shaft has been reported earlier (Rumapurkait 1996,Ref.10). This is not in correlation with the present observation. . Studies by Steyn and Iscan(Ref.13) reveal that all dimensions of femur were larger in males than in females, but determination of sex of an individual from a single femur was a more difficult task (TanerZiylan 2002,Ref.14). The shaft of femur is so shaped that it varies at mid-level and at subtrochanteric level. Hence several transverse and sagittal diameters are useful (Krogman 55,Ref.7).The values of three parameters namely, Vertical diameter of head, Neck-shaft angle and Transverse diameter of head in the present study shows. 75-80% percentage of accuracy of determining the sex of femur when compared to other parameters in this study.

Femora are categorized in to 1.Hyperplatymeric,2. Platymeric (flattened),3. Eurymeric (moderate) ,4. Stenomeric (rounded) groupsIn the present study 50 femora are categorized into1. **0**belongs to Hyperplatymeric,2.**6**belongs to Platymeric,3.**30** belongs to Eurymeric,4.**14** belongs to Stenomeric

Upper (Sagittal) Anteroposterior Diameter of shaft

Platymeric Index: -- x 100

Upper Transverse Diameter of Shaft

This study is to evaluate the subtrochanteric diameters (Anteroposterior and Transverse) in males and females and it is observed that more than 50 percent femora belong to **"Eurymeric"** group.

Every parameter independent of other contributes certain percentage of certainty to decide the sex of unknown femur. Therefore it is clear that based on no single parameter, sex of femur can be decided. All the parameters have to be considered together for this purpose.

IV. Summary And Conslusion

50 dry human femora of unknown sex were collected from different medical institution and Anthropology department of S. V. Universit, Tirupati. By eliminating pathologicaly misfit femora, 50 femora in good condition were selected. Each femur was carefully measured for 6 parameters which are already described in materials and methods. The measurements were statistically analyzed and tabulated.

For each femur accurate measurements are taken for 6 parameters namely:
1. Maximum length of femur
2. Vertical diameter of head
3. Epicondylar breadth
4. Neck-shaft angle
5. Transverse diameter of head
6. AP diameter of shaft – Upper,Middle,Lower

The measurements were compared to the values available in reference material. Every parameters is independent of others and contribute certain percentage of certainty to decide the sex of unknown femur. Therefore it is clear that based on no single parameter, sex of femur can be decided. All the parameters have to be considered together for this purpose.The present study reveals that femora of unknown gender can be sexed to the extend of 75-80% by three parameters namely, Vertical diameter of head, Neck-shaft angle and Transverse diameter of head.Every parameters is independent of others and contribute certain percentage of certainty to decide the sex of unknown femur. Therefore it is clear that based on no single parameter, sex of femur can be decided. All the parameters have to be considered together for this purpose.The present study reveals that femora of unknown gender can be sexed to the extend of 75-80% by three parameters namely, Vertical diameter of head, Neck-shaft angle and Transverse diameter of head.

Table –1 Anthropometric data of different parameters of human femora (mm)

S.No.	Femur No.	Side	Max. Length (mm)	Vertical diameter of head (mm)	Epicondylar breadth (mm)	Neck Shaft angle	Transverse diameter of head (mm)	AP diameter of shaft(mm)		
								Upper	Middle	Lower
1	1	Rt	415	41	75	122°	39	28	28	28
2	3	Rt	388	37	69	118°	35	25	23	25
3	5	Rt	408	39	72	128°	36	28	26	27
4	6	Rt	442	43	75	124°	40	28	26	28
5	8	Rt	444	42	74	130°	39	26	30	27
6	13	Rt	454	46	74	115°	40	27	29	30
7	14	Rt	412	44	74	126°	40	24	26	30
8	17	Rt	406	38	74	130°	38	26	25	28
9	18	Rt	502	48	75	130°	44	27	29	35
10	20	Rt	440	42	73	130°	39	23	27	28
11	23	Rt	482	47	78	128°	42	27	26	29
12	24	Rt	400	40	70	114°	35	28	22	24
13	25	Rt	430	42	74	130°	39	27	27	30
14	28	Rt	373	34	58	118°	28	22	22	24
15	30	Rt	440	42	78	128°	38	26	26	29
16	31	Rt	440	40	70	118°	35	28	27	26
17	32	Rt	444	46	78	125°	41	26	27	28
18	34	Rt	432	40	72	115°	36	25	26	27
19	38	Rt	475	43	80	129°	39	27	26	28
20	40	Rt	422	40	70	128°	36	25	24	28
21	41	Rt	462	42	76	130°	38	28	28	30
22	42	Rt	445	44	84	125°	38	26	27	29
23	43	Rt	392	40	72	118°	36	25	26	26
24	44	Rt	449	42	84	129°	40	32	28	33
25	46	Rt	434	40	74	116°	36	27	27	28
26	49	Rt	459	43	74	126°	38	25	26	26
27	50	Rt	458	39	70	130°	34	27	23	29
28	2	Lt	398	38	65	125°	35	27	24	27
29	4	Lt	409	44	77	135°	40	27	25	28
30	7	Lt	402	38	66	124°	35	27	24	27
31	9	Lt	443	43	74	135°	39	27	28	29
32	10	Lt	435	44	79	133°	41	28	30	30
33	11	Lt	475	45	83	126°	40	32	30	33
34	12	Lt	458	45	80	134°	39	26	30	32
35	15	Lt	418	42	72	106°	37	24	26	30
36	16	Lt	514	46	85	135°	42	27	28	29
37	19	Lt	392	38	73	116°	34	26	24	26
38	21	Lt	442	42	72	127°	38	27	26	28
39	22	Lt	498	51	92	126°	43	31	29	32
40	26	Lt	404	37	68	130°	34	22	22	24
41	27	Lt	438	50	78	125°	44	24	25	27
42	29	Lt	432	42	78	132°	34	24	27	28
43	33	Lt	422	41	74	126°	37	25	26	27
44	35	Lt	444	44	74	134°	37	29	27	30
45	36	Lt	465	43	80	120°	37	29	28	30
46	37	Lt	466	45	82	116°	37	27	26	31
47	39	Lt	430	43	78	122°	36	26	24	28
48	45	Lt	488	47	82	130°	42	30	30	34
49	47	Lt	457	45	82	128°	40	26	29	30
50	48	Lt	394	35	62	120°	33	24	24	25

Cont..

Table:2 Descriptive Statistics

Name of the variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Maximum Length	50	373.00	514.00	437.44	31.44	988.17
Vertical Diameter of Head	50	34.00	51.00	42.24	3.53	12.43
Epicondylar Breadth	50	58.00	92.00	75.06	6.06	36.71
Neck-shaft Angle	50	106.00	135.00	125.30	6.50	42.30
Transverse Diameter of Head	50	28.00	44.00	37.86	3.06	9.39
AP Diameter of Shaft UPPER	50	22.00	32.00	26.56	2.14	4.58
MIDDLE	50	22.00	30.00	26.38	2.18	4.77
LOWER	50	24.00	35.00	28.50	2.45	6.01
Valid N (listwise)	50					

Table:3 Group Statistics

Name of the variable	SIDE	N	Mean	Std. Deviation	Std. Error Mean
Maximum Length	Rt	27	435.11	29.680	5.712
	Lt	23	440.17	33.842	7.057
Vertical Diameter	Rt	27	41.63	3.090	0.595
	Lt	23	42.96	3.925	0.818
Epicondylar Breadth	Rt	27	73.96	4.996	0.961
	Lt	23	76.35	7.004	1.460
Neck-shaft Angle	Rt	27	124.44	5.700	1.097
	Lt	23	126.30	7.339	1.530
Transverse Diameter	Rt	27	37.74	3.058	0.589
	Lt	23	38.00	3.133	0.653
AP Diameter of Shaft UPPER	Rt	27	26.41	1.927	0.370
	Lt	23	26.74	2.397	0.500
MIDDLE	Rt	27	26.19	2.020	0.389
	Lt	23	26.60	2.388	0.498
LOWER	Rt	27	28.15	2.391	0.461
	Lt	23	28.91	2.503	0.522

No significant difference in femurs between right and left side

TABLE 4: REFERENCE VALUES OF FEMUR

Variables	Mean values of past studies references			Mean Values (T) Present Study	
		Mean	S.D	Mean	S.D
1. Maximum Length	1·Krogman M=	477.34	28.37		
	F=	439.10	24.55		
	2·Leelavathy.N M= L	443.30	15.40	R = 435.11	29.68
	R	443.20	14.60		
	F = L	404.20	30.60	L = 440.17	33.84
	R	401.80	33.10		
2. Vertical Diameter of head	1 Krogman M=	47.17	2.75	R = 41.63	3.09
	F=	41.52	2.12		
	2 Ruma purkait M=	74.23	4.90	L = 42.96	3.92
	F=	63.50	4.79		
3. Epicondylar breadth	1 Ruma Purkait M=	78.04	4.48	R = 73.96	5.00
	F =	67.13	3.92	L = 76.35	7.00
4. Neck shaft angle	1.W.J. Hamilton – 127⁰ (110-140⁰)			R = 122.44⁰	5.70
	2.Pick.JW et al - 126⁰ (104-147⁰)			L = 126.30⁰	7.33
5. Transverse diameter of head	1.Ruma purkait M=	44.28	2.48	R = 37.74	3.05
	F =	38.39	2.14	L = 38.00	3.13
6. AP diameter of shaft	1.Ruma purkait M=	27.95	2.12	Upper R = 26.40	1.93
	F =	23.38	1.79	L = 26.73	2.40
				Middle R = 26.20	2.02
				L = 26.61	2.40
				Lower R = 28.14	2.40
				L = 28.91	2.50

Table 5: Sexing of "Femur" by Individual Parameters

S.No	Parameters	Males	Females	N
1	Maximum Length	42	08	50
2	Vertical Diameter	23	27	50
3	Epicondylar Breadth	46	04	50
4	Neck-Shaft angle	24	26	50
5	Transverse diameter	22	28	50
	Upper	47	03	
	Middle	45	05	50
	Lower	50	00	

References
[1]. 1.Alan M. W. Porter1995 Analysis of measurements taken from adult femora of British population.
[2]. Asala . S.A. et al 2004 Discriminant function sexing of fragmentary femur of South African blacks, vol 145, issue 1. p. 25-29
[3]. Bannister Lawrence. H 1995 Gray's Text Book of Anatomy, 38th Edition P. 678-684
[4]. Hamilton W.J1976 Text book of human anatomy, 2nd Edition P. 117-120
[5]. Henry hollinsead. W1966 Text book of Anatomy, Indian edition (Hoeber medical division) P. 404-407 6.Henry Hollinshead. W 1958 Anatomy for surgeons, Vol-3 P. 654-657
[6]. Krogman, W.M and Iscan, M.Y`1986 Human skeleton in forensic medicine 2nd edition.
[7]. Leelavathy, et al 2000 Sexing of the femora, Journal of the Anatomical Society of India, Vol -49, no. 1, P. 17-20.
[8]. Mall G, Graw M et al 2000 Determination of sex from femora, Forensic science International, Vol – 113, No.1 P. 315-321
[9]. Purkait. R1996 Sex determination from femur: Standardization of measurement using fovea as land mark. J. Hum, Ecol, Vol-7, issue 1, P. 25-28.
[10]. Ruma Purkait2004 A study of sexual variation in Indian femur, Vol 146, issue 1, p:25-33.
[11]. Ruma Purkait2002 Review of Anthropometric techniques, Man in India, Vol -82 (issue 1 & 2) P. 185-191.13Steyn M. Iscan M1997 Sex determination from the femur and tibia in South African Whites, Forensic Science International, Vol – 90; P. 111-119.
[12]. Taner Ziylan2002 An Analysis of Anatolian Human femur Anthropomet6ry, Turkey Journal of Medical Sciences, Vol – 32, P. 231-235