ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 12, pp.62462-62467, December, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

MEASUREMENT OF NECK SHAFT ANGLE IN CADAVERIC FEMORA

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ARTICLE INFO

Article History:
Received 08th September, 2017
Received in revised form
14th October, 2017
Accepted 12th November, 2017
Published online 27th December, 2017

Key words:
Femur,
Neck-shaft angle,
Neck length, Neck width.

ABSTRACT

Femoral neck-shaft angle is important to convey the information regarding the race to which they belong. Awareness of normal neck-shaft angle with respect to sex and sides is useful to surgeons to treat the patients in different cases and also to design prosthesis. Hence the present paper was undertaken to determine the neck-shaft angle of femur in humans. Principal objective is to measure the neck-shaft angle, neck length and neck width in cadaveric femora. And also to find out the correlation between neck-shaft angle and neck length, neck width. The neck-shaft angle of cadaveric femora was measured by using Martin's dioptrograph and goniometer; other parameters by osteometric board, Vernier calipers and scale. There was no significant gender or side difference in neck-shaft angle. The combined mean values of neck-shaft angle, neck length and neck width were comparatively higher in males than in females, both in cadaveric femora and in radiographs. The mean neck-shaft angle positively correlated with neck length but not with neck width, oblique length and trochanteric oblique length in cadaveric femora.

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Citation: Dr. Nagarathnamma, B. 2017. "Measurement of neck shaft angle in cadaveric femora", *International Journal of Current Research*, 9, (12), 62462-62467.

INTRODUCTION

In bipeds, the hips have a great responsibility of transmitting the ground reaction against the body weight, while at the same time preserving mobility. To mechanically accommodate this postural change, the head and neck of femur undergo angulation and rotation locomotion from the very beginning (Kulkarni, 1999). The proximal femur in human is subjected to large variety and magnitude of force during day to day activities (Mishra *et al*., 2009). The hip joint is one of the largest and most stable joints in the body. It is a multiaxial ball-and-socket joint that has maximum stability because of the deep insertion of the head of the femur into the acetabulum (Kulkarni, 1999). The joint depends on the angle formed between the femur neck and the diaphysis, keeping the inferior limbs more distant from the pelvis and allowing greater rotation of the hip joint (DaSilva *et al*., 2003). The neck-shaft angle is defined as the angle formed by the neck axis and long axis of the shaft of femur.6It is also named as angle of neck of femur, angle of inclination, collodiaphyseal angle, cervicodiaphyscal angle (John Y Anderson and Erik Trinkaus, 1997) and caputcollumdiaphyseal angle. Normal neck-shaft angle varies from 120°-140°. A decrease in the normal neck-shaft angle is known as coxavara, while if the angle is more than 140° it is known as coxa-valga (Robert, 1996). The neck shaft angulation creates a weak spot at the upper end of femur.

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Nevertheless the angulation constitutes important feature of adaptation that helps in the process of evolution of erect posture in bipeds. The angulation was studied extensively by many workers and conclusions were drawn. It was found to be different in different races and at different ages. The findings pertaining to sex were inconsistent. However it was described as greater in males than females, or no sexual difference at all. The knowledge of the angle of inclination is a valuable aid in the diagnosis and treatment of the fractures of upper end of femur. Knowledge of the anatomy of proximal end of femur is a prerequisite for a complete understanding of the mechanics of the hip joint and serves as a basis for the treatment of pathological conditions of the hip and femur.6 Abnormalities in the anatomic development of proximal femur in children with cerebral palsy remain primary contributors to the significant hip problems and gait disturbances in these patients (Eugane D. Bobroff *et al*., 1999). The availability of geometrical data describing the proximal femur allows guidelines to be developed for the functional dimensions of femoral component. These anatomic data also allow assessment of the match between the shape of the existing components and the proximal femur (Mishra *et al*., 2009). The length of the femur and stature are of forensic and anthropological significance. Bony markers such as the head and neck of femur can be used in determining the femoral length when only a fragment of proximal femur is available (Rajendra Prasad *et al*., 1996). Anthropometric study of the bones is important to convey the information regarding the race to which they belong and also useful for surgeons, for treatment of fractures by internal fixation (Kate, 1964). Knowledge of normal asymmetry of right and left neck-shaft angle of femur may be a great value in evaluation of patients with known or assumed pathological conditions and in correctional osteotomies in cases of femoral fractures. The neck-shaft angle can be estimated from a proximal femoral fragment and the required size of the length of the neck can be determined to design prostheses for the restoration of normal neck-shaft angle (Isaac *et al*., 1997). Awareness of the anatomic differences between genders for acetabularanteversion angle and neck-shaft angle may help to reduce the relatively higher incidence of dislocations in females and may lead to different implant designs for male and female patients. It is important to know the normal acetabular and femoral anteversionangle for proper implant positioning and to prevent dislocation in total hip arthroplasty (Masaaki Maruyama *et al*., 2001). Considering the above factors, the present study was undertaken to measure the neck-shaft angle of femur in adult human cadaveric bones for better understanding of the proximal end of femur.

MATERIALS AND METHODS

The present study was conducted on dry human cadaveric femora and radiographs of living subjects. 100 adult dry human cadaveric femora were collected from the Department of Anatomy, J.J.M. Medical College, Davangere. Specimens which showed osseous pathology, previous fracture, damaged, burnt and abnormal bones, bones of children and old age were excluded from the study. Femora of adult human having all the component parts were included in the present study. Side determination of the femora was done by using classic anatomical features. The head facing upwards, medially and slightly forwards. Convexity of the shaft facing forwards. The sexing of the femora was done according to the Pearson's table of "mathematical sexing of femora". Following measurement were recorded for the sexing of the femora.

Oblique length of femur (OL): It measures the distance from the highest point of the head to the infracondylar plane.

Trochanteric oblique length (TOL): It measures the vertical distance from the top of the greater trochanter to the infra condylar plane.

These measurements were taken using osteometric board.

Vertical diameter of the head (VDH): It measures a straight distance between the highest (proximal) point of the head to the deepest (distal) point on the inferior aspect of the head.

Bicondylar width (BW): It measures the distance between the medial and lateral epicondyles taken parallel to the infra condylar plane.

Popliteal length (PL): It measures the distance from the apex of the popliteal surface of femur to the centre of the intercondylar plane. These measurements were taken using sliding calipers and scale. Measurements of neck length and neck width in dry bones were recorded using sliding calipers and scale.

Neck length (NL): It measures the distance from the head-neck border to the inter trochanteric crest.

Neck width (NW): It measures the minimum distance between superior and inferior margins of the neck.

Measurement of the neck-shaft angle: The neck-shaft angle in dry human adult femora was measured by using 'Martin's dioptrograph', A4 size drawing sheets, pencil lead, scale and goniometer or protractor.

Procedure: First the A4 size drawing sheet was fixed to the wooden drawing board. Pencil lead was inserted in the pencil holder and the femur was placed in the centre of the adjustable wooden board. Looking into the telescope, the crossing point was approximated to the margins of the image (contour) of the bone and moved, tracedupto the ¾ of the shaft, then shifted to the other side and traced till it meets the starting point. Meanwhile as the lines were traced, the contour of the bone was produced on the drawing sheet. Drawing sheet was then removed from the board. The frame of the pantograph can be adjusted to get various scales 1/2, 1/3, 1/4, 1, 2 and 3. After removing the drawing sheet, the neck axis and shaft axis were drawn. Neck axis is drawn by locating the mid point of the neck by measuring the width of the narrowest portion of the neck and dividing by two. A line from the centre of the head of femur through the centre of the neck gives the neck axis. Shaft axis is drawn by using a line through the centre of the shaft of femur. The angle formed by these two axes was measured using goniometer and recorded.

RESULTS

In the present study 100 femora (male and female) were studied for neck-shaft angle, neck length and neck width on both right and left sides. The neck-shaft angle in the male right femora ranged from 122°-141° with a mean of 132.8±4.3°, while in the male left femora it ranged from 113°-150° with a mean of 134.5°±4.5°. There was no significant side difference ($p=0.22$) seen in the male femora. The neck-shaft angle in the female right femora ranged from 121°-142° with a mean of 130.5°±4.7°, while in the female left femora it ranged from 113°-146° with a mean of 132.0°±6.1°. There was no statistically significant side difference ($p=0.33$) in the female femora. Neck shaft angle did not show any statistically significant sex difference (Table 1, Graph 1). The neck length in the male right femora ranged from 25-35mm with a mean of 30.0±3.3mm, while on the left side femoral neck length ranged from 23-28mm with a mean of 29.9±3.5mm. There was no statistically significant side difference in the male femora ($p=0.95$). In the female right femora the neck length ranged from 23-40mm with a mean of 28.3±4.2mm, while in the female left femora, the neck length ranged from 23-36mm with a mean of 27.5±3.1mm. There was no statistically significant side difference ($p=0.40$). The neck length showed no statistically significant sex difference (Table 1, Graph 3). The neck width in the male right femora ranged from 27-34mm with a mean of 29.7±1.9mm while in the male left femora the neck width ranged from 24-38mm, with a mean of 33.3±2.9mm. Comparison of neck length width in male with respect to side showed a statistically significant difference with p-value of <0.001. In the female right femora the neck width ranged from 20-29mm with a mean of 24.7±2.6mm, while in the left femora the neck width ranged from 20-36 mm with a mean of 28.3±4.1mm. Comparison of neck width in the female with respect to side showed a statistically significant difference with p-value <0.001 (Table 1, Graph 5). The mean neck shaft angle in the male femora on both the sides showed significant positive correlation with the mean neck length ($p<0.05$) on both the sides, whereas in the females, the value on the right side was significant ($p<0.05$), but on the left side the neck shaft angle has no statistically significant correlation with neck length (p=0.27) (Table 3, Graph 7).

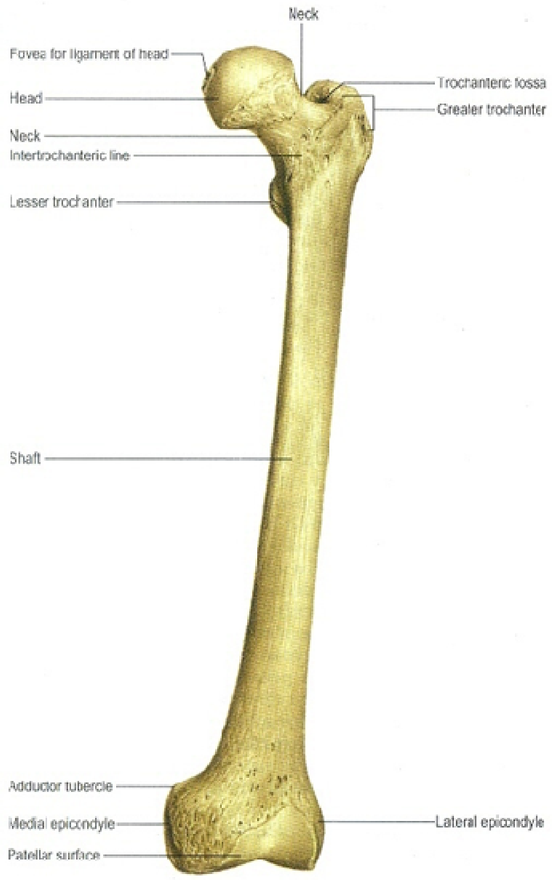


Fig.A : Anterior aspect of femur

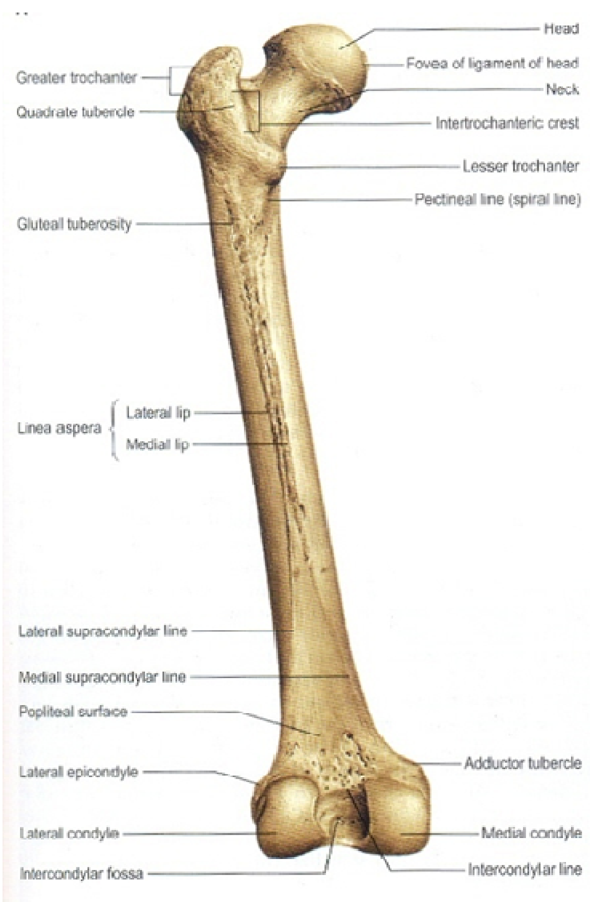


Fig.B :Posterior aspect of femur

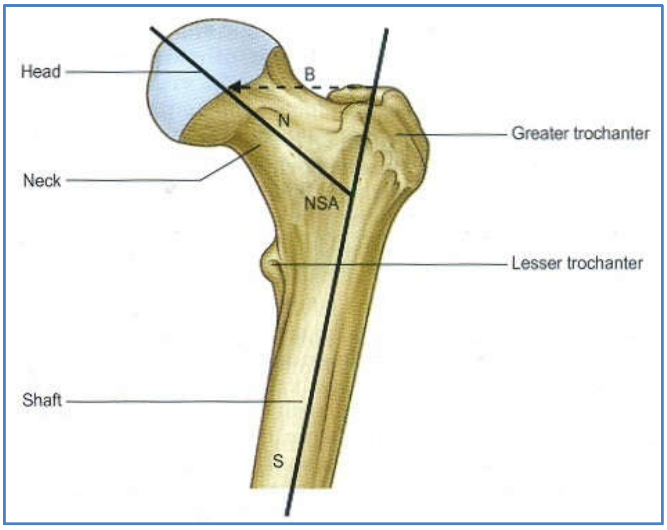


Fig.C : The neck shaft angle between the long axis of the shaft and axis of the femoralneck

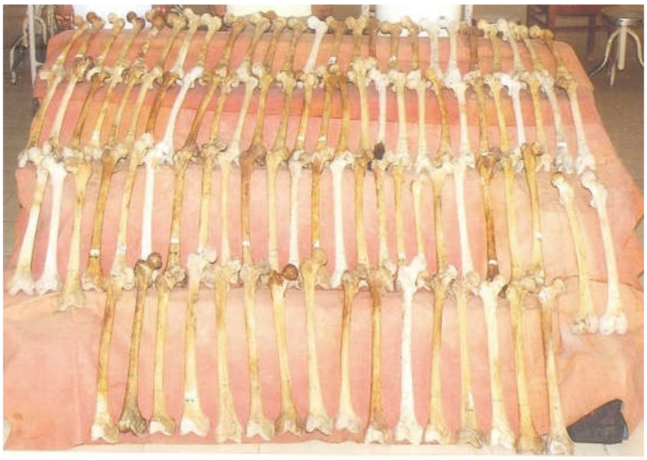


Fig. E : 100 Femora

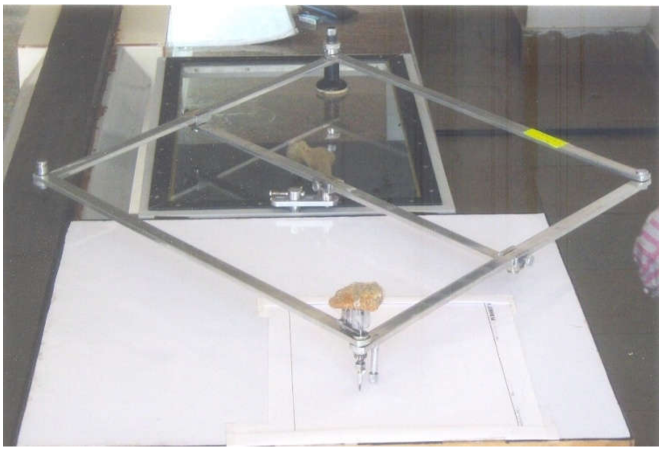


Fig. I : Martin's dioptrograph

Measurements for mathematical sexing of femora

Measurement	Female	Female?	Sex?	Male?	Male
Vertical diameter of head	41.5	41.5–43.5	43.5–44.5	44.5–45.5	45.5
Popliteal length	106	106–114.5	114.5–132	132–145	
Bicondylar width	72	72–74	74–76	76–78	78
Trochanteric oblique length	390	390–405	405–430	430–450	450

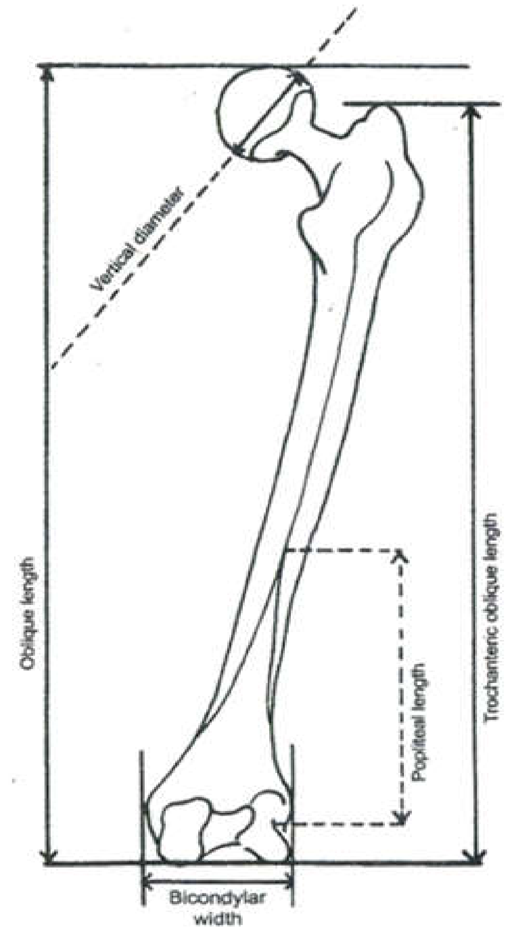


Fig. K : Diagram of right femur showing measurements referred to in table below

Table 1. Cadaveric femora

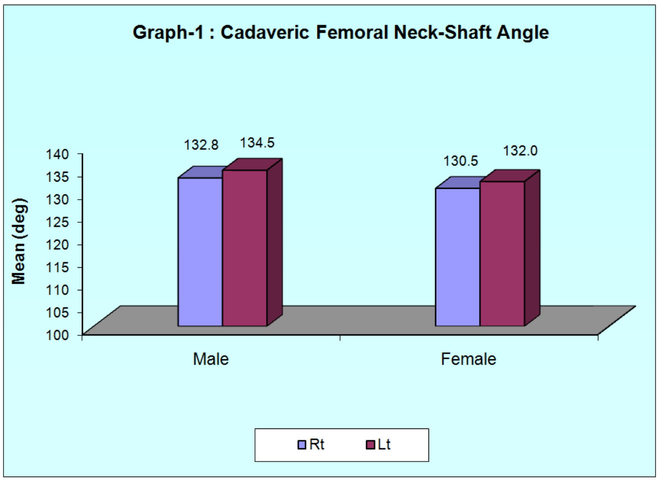
		NSA (degree)			NL (mm)			NW (mm)		
		Rt	Lt		Rt	Lt		Rt	Lt	
Male	Mean±SD	132.8±4.3	134.5±4.5	t=1.24 p=0.22 NS	30.0±3.3	29.9±3.5	t=0.07 p=0.95	29.7±1.9	33.3±2.9	t=5.19 p<0.001
	Range	122-141	113-150		25-35	23-28	NS	27-34	24-38	HS
Female	Mean±SD	130.5±4.7	132.0±6.1	t=0.98 p=0.33 NS	28.3±4.2	27.5±3.1	t=0.85 p=0.40	24.7±2.6	28.3±4.1	t=3.83 p<0.001
	Range	121-142	113-146		23-40	23-36	NS	20-29	20-36	HS
M vs F	t	1.73	1.69		1.47	2.64		8.32	5.11	
	p	0.10 NS	0.09 NS		0.15 NS	<0.05 S		<0.001HS	<0.001HS	

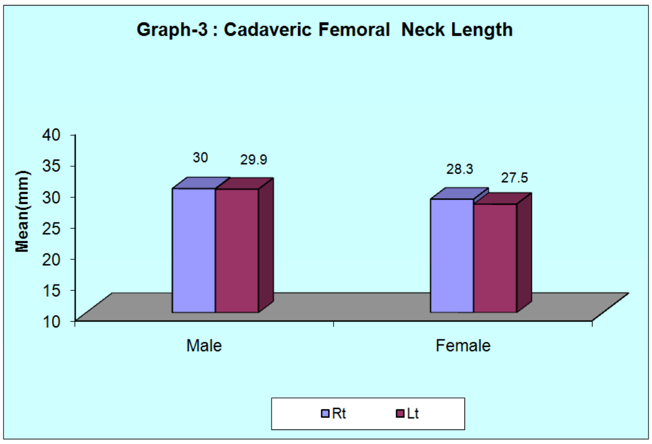
Table 2. Cadaveric femora (100)

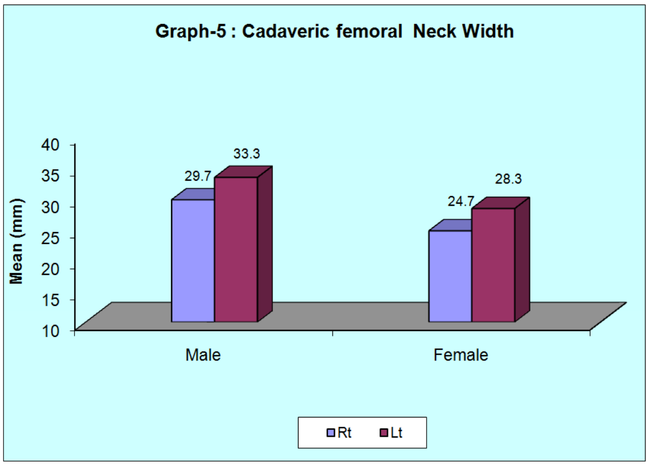
Correlation between	Cadaveric femora (100)								Radiograph (20)	
	Males				Females					
	Rt		Lt		Rt		Lt			
	r-value	p	r-value	P	r-value	p	r-value	p	r-value	p
NL and NSA	+0.53	<0.05 S	+0.38	<0.05 S	+0.43	<0.05 S	+0.22	0.27 NS	+0.40	<0.05 S
NW and NSA	+0.06	0.78 NS	-0.01	0.99 NS	-0.14	0.50 NS	0.01	0.97 NS	+0.21	0.20 NS
OL and NSA	+0.10	0.67 NS	-0.16	0.43 NS	-0.25	0.15 NS	-0.15	0.40 NS	-	-
TOL and NSA	+0.05	0.82 NS	-0.27	0.18 NS	-0.33	0.10 NS	-0.18	0.37 NS	-	-

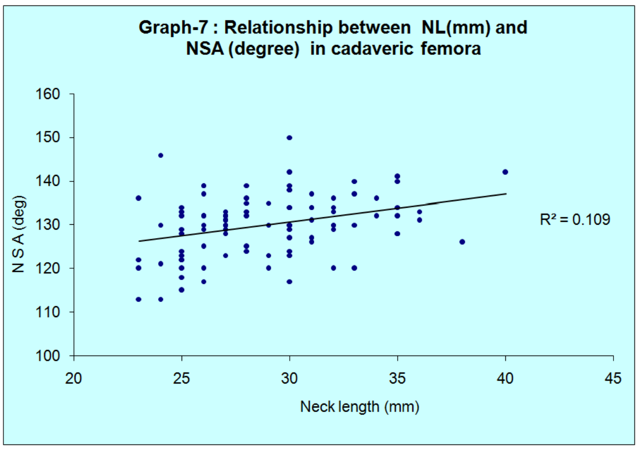
Table 3. Cadaveric femora

	NSA (degree)			NL (mm)			NW (mm)		
	Rt	Lt	Combined	Rt	Lt	Combined	Rt	Lt	Combined
Male	132.80±4.3	134.50±4.5	133.65± 4.4 113-150	30.0±3.30	29.90±3.50	29.95± 3.40	29.70±1.90	33.3±2.9	31.50 ± 2.40
	122-141	113-150		25-35	23-28		27-34	24-38	
Female	130.50±4.7	132.00±6.1	131.25±5.40 113-146	28.30±4.20	27.50±3.65	27.90± 3.65	24.70±2.60	28.3±4.1	26.50 ± 3.35
	121-142	113-146		23-40	23-36		20-29	20-36	
M+F	131.65±4.5	133.25±5.3	132.45±4.90	29.15±3.75	28.70±3.30	28.92±3.52	27.20±2.25	30.8±3.5	29.0±2.87









The mean neck-shaft angle in both the male and female femora, on both the right and left sides did not show significant correlation with mean neck width. In male femora p-value on the right side was 0.50, while on the left side it was p=0.97 (Table 3). The mean neck-shaft angle in both the male and female femora on both the sides did not show significant positive correlation with the oblique length (Table 3). The mean neck-shaft angle in both the sexes on both the sides did not show positive correlation with the trochantric oblique length (Table 3).

Conclusion

The mean neck-shaft angle of the male femora was comparatively higher than in the female, but statistically not significant. The mean neck-shaft angle of the left femora was higher than in the right femora but not statistically significant. The mean neck length of the male femora was significantly higher than in the female femora. There was no significant difference in the mean neck length with respect to side. The mean neck width of the left femora was higher, when compared to the right femora, which was statistically highly significant. A positive correlation was observed between mean neck-shaft angle and neck length of femora.

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