STUDY OF PROXIMAL FEMORAL MORPHOMETRY BY RADIOGRAPHY AND ITS CORRELATION WITH BODY MASS INDEX

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ABSTRACT

Body mass index and different morphometry indices of proximal femur are important determinants of fracture neck femur which is considered to be a health burden of our society. In this study fifty people aged more than fifty years were selected randomly after interview and examination. Morphometric measurements were performed on the skiagrams at the left side. Base line values like age, weight, height were recorded and BMI was calculated. Correlation between different morphometric indices of proximal femur and BMI was determined after statistical analysis with Epi-info 3.5.1. For weight and height, moderate to poor correlation was obtained with femoral morphometric indices. Strong to moderate correlation was seen between BMI and indices. Good correlation was also seen for sex with morphometry except neck shaft angle and intertrochanteric length.

KEY WORDS: Proximal femoral morphometry, Body mass index, correlation coefficient.

INTRODUCTION:

There are metric differences in skeletal components among populations and these variations are related to genetic and environmental factors. Interest in the measurement of the dimensions and geometry of the proximal femur as part of the assessment of fracture risk was spurred by the initial recognition of hip axis length (HAL) as an independent predictor of hip fracture risk. Other measures have also come under scrutiny as predictors of hip fracture risk like neck-shaft angle, femoral neck width etc. Several studies have found significantly greater femoral neck-shaft angles in hip fracture patients than in controls, whereas other has not[1,2]. Femoral neck width is measured at the narrowest part of the femoral neck. An increase in neck width from periosteal bone apposition has been postulated as a compensatory response to a decrease in bone density. If this is so, the increase in femoral neck width in the presence of a low bone density should indicate a reduction in fracture risk compared to individuals with an average or reduced neck width and the same low bone density. Findings from various researchers, however, have been mixed[1, 2, 3]. Femoral head width is the broadest cross-section of the femoral head. An increase in head width from periosteal bone apposition has been postulated as a compensatory response to a decrease in bone density. It may also occur in delayed response to avascular necrosis of femoral head[1,2].

Moreover, body mass index is also an important determinant of fracture neck of femur as well as nutritional status of a person[2, 3]. So, the aim of our study was to find out correlation between different anthropometric measurements and proximal femoral morphometry among the study population.

MATERIALS & METHODS:

We conducted an observational descriptive study with cross-sectional design of data collection where patients were selected from the O.P.D. of Radio diagnosis, Medical College & Hospital, Kolkata. One day in a week was selected randomly and it came out to be Wednesday. Persons above 50 years of age coming for x-ray during study hours (10am-1 pm) were selected as study population. For all patients skiagrams of left femur were obtained for uniformity. Consent of the patient was taken in each case. Thereafter, interview of the patient was taken and thorough examination was performed to exclude the diseases which could modulate the outcome of the study (Injury of the study part of limb, metabolic bone diseases, malignancy, renal failure, coxarthrosis). Total final sample size was 50 following inclusion and exclusion criteria. The study duration was from May 2010-April 2011.

Pelvic radiograms were taken with 15-30 degrees of internal rotation of the hips in the supine position. The beam centered on the symphysis pubis with a film-focus distance of 100 cm. 15 inch x 12 inch films were used in this study. 100-120 KV with 80-90

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mAs was applied for pelvic radiograms according to the physical status of the person.

Baseline values were recorded including weight, height, sex and body mass index. For measuring the weight the scale was placed on a hard, flat and even surface. The person was requested to stand atop the scale. He/she was asked to remain still for accurate calc lation. No recording was taken until the dial stopped moving. The procedure was done thrice and average value was calculated.

For measuring the height patient was asked to remove bulky clothing, including shoes and hair ornaments. The person was requested to stand against a wall facing outwards and looking straight forward keeping the head in Frankfurt plane. His or her head, shoulders, rear end and heels touched the wall. A ruler was gently pressed down on the top of the head. The spot was marked where the ruler touches the wall with a pencil. The person was asked to step away from the wall and a tape was used to measure the vertical height.

Body mass index was calculated as weight (kilograms) divided by the square of height (metres) [kg/m2].

For morphometric measurements transparent films were taken. One longitudinal line was drawn over the film. Few perpendicular lines 1 cm apart were also drawn on that longitudinal line. The film was placed over the radiograms in order to facilitate accuracy and consistency of the measurements and points of desired measurements were marked over the lines. Thereafter the linear measurements were taken from the transparent films by a scale. For measuring angle, a protractor was used after drawing the accurate lines over the radiograms. The measuring techniques conformed to the existing literature[2,4-8].

Following measurements were taken on the radiogram (Fig-1):

1. HAL [Hip axis length] (C-D): length of the femoral neck axis from the base of the lateral part of the greater trochanter to the inner pelvic brim.
2. FAL [Femoral neck axis length] (A-B): length of the femoral neck axis from the base of the lateral part of the greater trochanter to the caput femoris.
3. HW [Femoral head width] (E-F): broadest cross-section of the femoral head.
4. FW [Femoral neck width] (G-H): narrowest cross-section of femoral neck.
5. TW [Intertrochanteric length] (I-J): cross-section from immediately above the lesser trochanter to the most lateral aspect of the greater trochanter.
6. NSA [Neck shaft angle]: angle between femoral neck and shaft of femur.

Collected data was tabulated in Microsoft excel spread sheet and was analyzed by Epi-info 3.5.1. Software.

RESULT & ANALYSIS:

Study was conducted among 50 persons which included 17 males (34%) and rest females. Among the study population, 17 were normal weight (male 29.4%) whereas 28 were overweight (males 35.7%) and rest were grade II obese (male 40%). Underweight, grade I & III obese persons were not found during the study period. Mean age of the study population was 59 years with SD of 4.63 years. Mean weight of the study population was 71.02 kg with SD of 9.16 kg. Mean of height was 1.64 meter with standard deviation 0.06 meter. Mean BMI was 26.43 with standard deviation 3.71. The mean ± SD of the six parameters were recorded as follows: FAL (10.044 ±1.03cm), FW (2.6 ± 0.49cm), HAL (9.8± 0.75cm), HW (4.89± 0.28cm), NSA (125.04 ± 2.06cm) and TW (6.42 ±0.26cm). Table I shows mean ± SD of various parameters according to sex. 'P value < 0.05' indicates that the result is statistically significant.

Table I: Various parameters in males and females.

Parameters	Sex		Test of significance
	Male(n=17)	Female(n=33)	
Height (meter)	1.63±0.06	1.65±0.05	T=1.16, p=0.25(>.05)
Weight(Kg)	70.65±9.39	71.21±9.17	T=0.20, p=0.84(>.05)
BMI	26.69±3.93	26.29±3.65	T=0.36, p=0.72(>.05)
FAL (cm)	10.01±0.99	10.01±1.06	T=0.16, p=0.88(>.05)
FW (cm)	2.65±0.45	2.57±0.57	T=0.52, p=0.60(>.05)
HAL (cm)	9.69±0.80	9.85±0.72	T=0.72, p=0.48(>.05)
HW (cm)	4.96±0.24	4.85±0.29	T=1.33, p=0.19(>.05)
NSA (degree)	125.53±2.18	124.79±1.98	T=1.21, p=0.23(>.05)
TW (cm)	6.50±0.32	6.38±0.22	T=1.58, p=0.12(>.05)

Table II: Correlation coefficients(r) of height, weight, BMI and age with six morphometric parameters.

Parameters	weight	height	BMI	age
FAL	0.671	0.245	0.755	0.173
FW	0.775	0.283	0.894	0.1
HAL	0.173	0.1	0.224	0.0
HW	0.686	0.224	0.762	0.173
NSA	0.141	0.224	0.225	0.0
TW	0.4	0.361	0.557	0.1

The quantity r, called the linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables. The value of r is such that $-1 < r < +1$. The + and signs are used for positive linear correlations and negative linear correlations, respectively.

$r = \geq +0.8$ or ≤ -0.8 indicate strong correlation.

$r = -0.79$ -0.3 or +0.3 -- +0.79 indicate moderate correlation.

$r = +0.29$ or ≥ -0.29 indicate less or weak correlation.

$r = 0$ indicate no correlation[4,8].

Table III: Linear regression equations for prediction of femoral morphometric indices taking height, weight separately and in combination as BMI.

Parameters	With height	With weight	With BMI
FAL	=17.251-4.392X ht	=4.685+0.075X wt	=4.543+0.208X BMI
	r^2= 0.06	r^2= 0.45	r^2= 0.57
FW	=6.808-2.566X ht	= -0.368+0.042X wt	= -0.541+0.119X BMI
	r^2= 0.08	r^2= 0.60	r^2=0.80
HAL	=11.408-0.98X ht	=8.758+0.015X wt	=8.623+0.045X BMI
	r^2= 0.01	r^2= 0.03	r^2=0.05
HW	=6.744-1.132X ht	=3.399+ 0.021X wt	=3.369+ 0.057X BMI
	r^2= 0.05	r^2= 0.47	r^2=0.58
NSA	=138.893-8.442X ht	=122.88+0.03X wt	=121.409+0.137X BMI
	r^2= 0.05	r^2= 0.02	r^2= 0.06
TW	=9.133-1.653X ht	=5.611+0.011X wt	=5.38+0.039X BMI
	r^2= 0.13	r^2= 0.16	r^2= 0.31

The coefficient of determination, r^2, is useful because it gives the proportion of the variance (fluctuation) of one variable that is predictable from the other variable. It is a measure that allows us to determine how certain one can be in making predictions from a certain model/graph. The coefficient of determination is the ratio of the explained variation to the total variation.

The coefficient of determination is such that $0 < r 2 < 1$ and denotes the strength of the linear association between x and y.

The coefficient of determination represents the percent of the data that is closest to the line of best fit. For example, if $r = 0.922$, then $r 2 = 0.850$, which means that 85% of the total variation in y can be explained by the linear relationship between x and y (as described by the regression equation).

The other 15% of the total variation in y remains unexplained. The coefficient of determination is a measure of how well the regression line represents the data. If the regression line passes exactly through every point on the scatter plot, it would be able to explain all of the variation. The further the line is away from the points, the less it is able to explain[4,7,8].

Table IV: Correlation coefficients(r) of BMI with femoral morphometric indices separately among males and females and among normal BMI (16.5-18.49) and abnormal BMI persons (<16.5 or ≥18.5) in the study population (n=50)

Femoral morph metric indices	Among sex group		Among BMI groups	
	Males (n=17)	Females (n=33)	Normal BMI(n=17)	High/low BMI(n=33)
	BMI	BMI	BMI	BMI
FAL	0.8	0.735	0.361	0.742
FW	0.933	0.871	0.85	0.927
HAL	0.4	0.141	0.387	0.616
HW	0.854	0.735	0.592	0.671
NSA	0.173	0.283	0.316	0.265
TW	0.707	0.458	0.435	0.4

OBSERVATION:

No significant difference was observed between males and females regarding the study variables [p>0.05] (table-I).

It was also found that BMI was the better predictor of all the six indices. Age was the poorest predictor in all cases (table-II).

The r^2 was highest for BMI. The r2 was all the way low for HAL and NSA showing that they may not be better explained by linear equations (table-III).

Among males high correlations were obtained for FW, HW and FAL ($r = \geq +0.8$). Moderate correlation with TW and HAL (r = +0.3 -- +0.79) and poor correlation with NSA (r = +0.29). Among the females only FW showed high correlation while HAL and NSA showed poor correlation. Among the abnormal BMI cases FW only showed high correlation while only NSA showed poor correlation. Among the normal BMI patients FW also showed high correlation while all others showed moderate correlation (table-IV).2

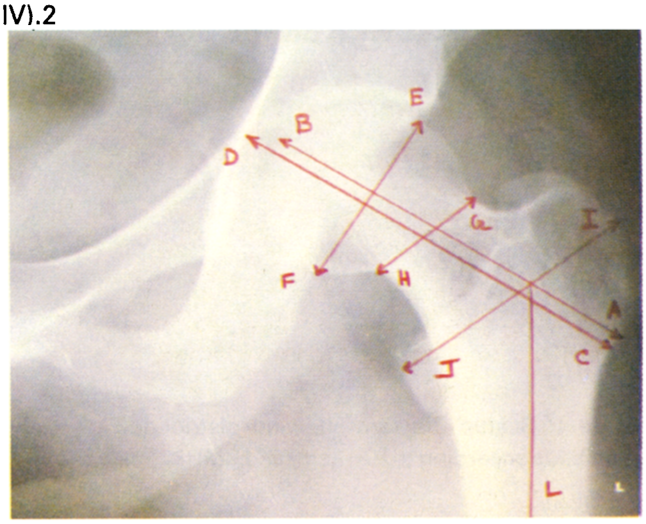

Fig-1: showing different morphometry indices of proximal femur.

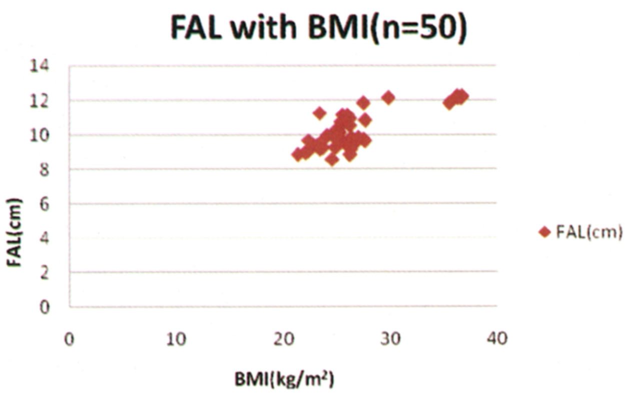

Figure-2: Scatter diagram showing distribution of study population according to FAL (cm) and BMI (kg/m2).

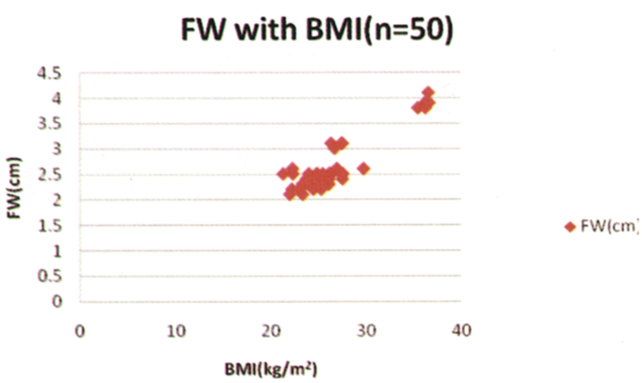

Figure-3: Scatter diagram showing distribution of study population according to FW (cm) and BMI (kg/m2).

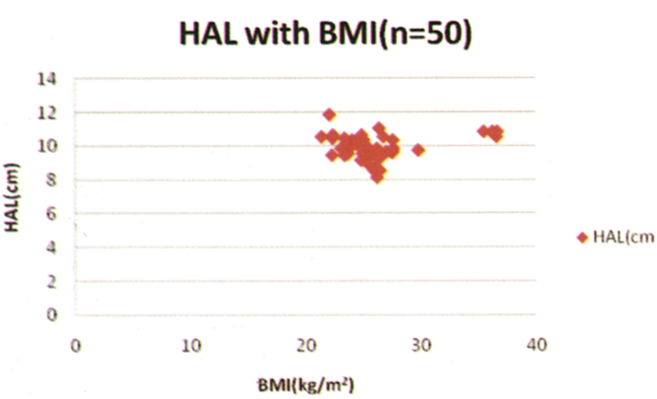

Figure-4: Scatter diagram showing distribution of study population according to HAL (cm) and BMI (kg/m2).

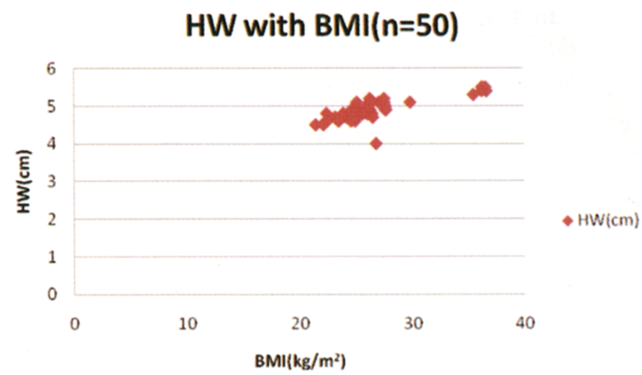

Figure-5: Scatter diagram showing distribution of study population according to HW (cm) and BMI (kg/m2).

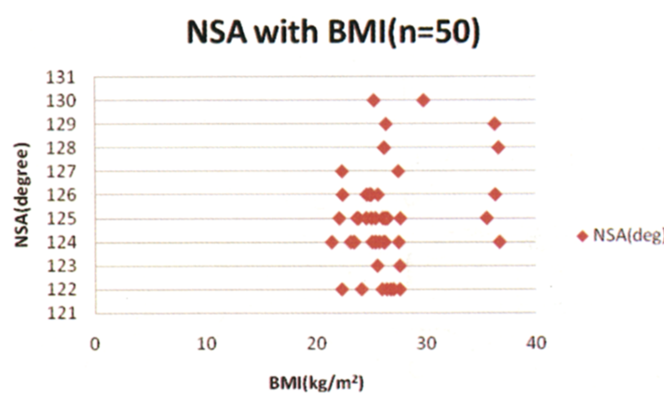

Figure-6: Scatter diagram showing distribution of study population according to NSA (degree) and BMI (kg/m2).

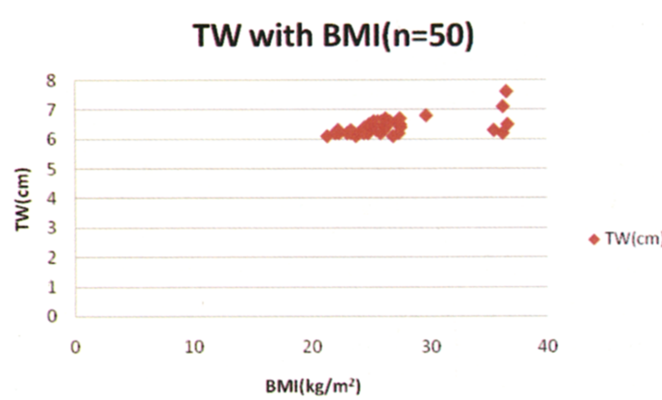

Figure-7: Scatter diagram showing distribution of study population according to TW (cm) and BMI (kg/m2).

List of Abbreviation:

1 C-D: HAL (HIP aseis length)
2 A-B: FAL (Femoral neck aries Length
3 E-F: HW (Femoral head Width)
4 G-H: FW (Femoral neck Width)
5 I-J: TW (Interrochainteric Length)
6 NSA: Neck Shaft angle

DISCUSSION:

The shape of the proximal femur is known to be an important risk factor for hip fracture of the femoral neck, regardless of bone mass or bone strength. A bone fractures when it is subjected to stresses greater than its ultimate strength [9].

The stress within a bone depends on the geometric arrangement and the material of which the bone is made, as well as on the direction and size of the force applied[10-12]. The risk of hip fracture can be predicted by some factors, such as body mass index, bone mineral density, the direction and severity of the fall, muscle strength, body habitus, femoral morphometry, family history or lifestyle factors[2,4,8]. This finding suggests that proximal femoral morphometry may be an important factor in determining hip fracture risk. However, there are discrepancies concerning the effect of proximal femoral morphometry on fractures. These discrepancies may be due to racial differences in proximal femoral morphometry among populations 13, 14. Femoral morphometric parameters have been related to the mechanical strength of the proximal femur. These parameters are also involved in the resistance of bone against impact, the highest values being found in races with a higher incidence of hip fracture 9, 15, 16.

Some of the most frequently described measurements that have been associated with an increased risk of fracture include a longer hip axis length of femur[6,9,17] ; a larger femoral neck-shaft angle [5,6,9,11,17] and a larger femoral neck width[5,6,9,17]. The precise physical mechanism of this is unknown, since it contradicts data from in vivo biomechanical tests showing a positive correlation between hip axis length and femoral neck strength[14,18].

J. Irdesel and I. Ari (2006) found positive correlation between FW, HW, TW and body mass index[19]. In the present study no significant correlation was found between weight and HAL or NSA (r = +0.29). Only moderate correlation was obtai ed between weight and rest of the morphometric indices (r = +0.3 -- +0.79). Moderate correlation was detected between height and TW. No significant correlation was found between height and rest of the morphometry indices. Very strong correlation was established between BMI and FW(r = ≥ +0.8). Moderate correlation was found between BMI and FAL, HW or TW. Moderate correlation was also found between BMI and FAL, HW, HAL, NSA, TW in normal BMI population. Among the high BMI persons, very strong correlation was found between BMI and FW. Only moderate correlation was found between BMI and FAL, HAL, HW in those cases. Better correlation was established between BMI and all morphometric indices except NSA in male population. In literature we find mean HAL was 6.3-10.8cm[6,19,20,21,22]; mean FAL was 9-10.1cm19,21,22; mean FW was 2.9-3.5cm[6,19,20,22]; mean TW was 5.2-8.4cm20,22; mean HW was 4.3-5.2cm[19,22] and mean NSA was 122.6-131.5degree6,[19,20,22.] Among these average results, mean of FW of present study was lower than those of previous studies.

So, the present study establishes the relation among proximal femoral morphometry and sex, weight, height, BMI of the population. Moreover, if one variable is known, the other one can be predicted.

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