The Relation Between T-score, Z-score, Bone Mineral Density and Body Mass Index

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Abstract:
This study was performed to evaluate the relationship between Body Mass Index (BMI) and Bone Mineral Density (BMD) and the effect of age on BMD .this study included 150 Jordanian women: these women benefited from the measurement of bone density of the lumber spine (L_2- L_4), and the femoral neck by the DXA method .age ranged from 21 to 89years (59±14.21) .BMI was calculated (25.88±357) kg/ $(m)^2$. A strong ,positive relation between LS.BMD and Neck.BMD was confirmed (R = 0.534, $P \leq 001$) .when Age and BMI were related to BMD independently linear regression analysis revealed significant positive associations between lumber BMD and BMI ($P \leq 0.01$) and significant negative associations with age ($P \leq 005$) .
Keywords: Body Mass Index (BMI), Bone Mineral Density (BMD), obesity, osteopenia, osteoporosis, T-score, Z-score, Correlation factor. (r), DEXA.

1. Introduction:

A bone mineral density (BMD) test measures the density of minerals (such as calcium) in the bones using a special X-ray or computed tomography (CT) scan. This information is used to estimate the strength of bones. We all lose some bone mass as we age. Bones naturally become thinner (called osteopenia) as you grow older because existing bone is broken down faster than new bone is made. As this occurs, our bones lose calcium and other minerals and become lighter, less dense, and more porous. This makes the bones weaker and increases the chance that they might break (fracture).With further bone loss, osteopenia leads to osteoporosis.

1.1 Bone Mineral Density Measurement:

Dual X-ray absorptiometry (DXA) is the preferred technique for measuring bone mineral density (BMD). DXA has also been called dual energy X-ray absorptiometry, or DEXA. DXA is relatively easy to perform and the amount of radiation exposure is low. A DXA scanner is a machine that produces 2 X-ray beams, each with different energy levels. One beam is high energy while the other is low energy. The amount of X-rays that pass through the bone is measured for each beam. This will vary depending on the thickness of the bone. Based on the difference between the two beams, the bone density can be measured. At present, DXA scanning focuses on two main areas the hip and spine. Although osteoporosis involves the whole body, measurements of BMD at one site can be predictive of fractures at other sites. Results of bone mineral density tests can be reported in two numbers: T-score and Z-score. Your T-score is your BMD compared to the average score of a healthy 30-year-old. It is expressed as a standard deviation (SD), which is a statistical measure of how closely each person in a group is to the average (mean) of the group. The average BMD is determined by measuring the bone density of a large group of healthy 30-year-olds (young adult reference range). BMD values are then reported as a standard deviation from the mean of this reference group. Almost all 30-year-old people have a BMD value within 2 standard deviations of this mean. The following table contains the World Health Organization's definitions of osteoporosis based on bone mineral density T-scores.

T-score	What your score means
-1 and above	Your bone density is considered normal.
Between -1 and -2.5	Your score is a sign of osteopenia, a condition in which bone density is below normal and may lead to osteoporosis.
-2.5 and below	Your bone density indicates you have osteoporosis.

Your Z-score is the number of standard deviations above or below what's normally expected for someone of your age, sex, weight, and ethnic or racial origin. If your Z-score is -2 or lower, it may suggest that something other than aging is causing abnormal bone loss.

1.2 Body Mass Index:

The body mass index (BMI) is a measure for human body shape based on an individual's weight and height. . Body mass index is defined as the individual's body mass divided by the square of their height.

The world health organization regards a BMI of less than 18.5 as underweight, while a BMI greater than 25 is considered overweight and above 30 is considered obese.

2. Subjects and Methods:

2.1 Participants:

150 women were selected from the ladies revisions for orthopedic clinics in the Jordanian hospitals for measurement of BMD by DXA during the period 25- Sep- 2011 to 4- Feb- 2013, aged (21 years old to 89 years old) the range of 68 years and average 59 years old and a standard deviation (14.214) years. Ladies have been classified by the World Health Organization's definition to obese women, and women with overweight, and women with normal weight.

2.2 Measurements:

The bone mineral density (BMD) was measured at the lumbar spine (L2 - L4) and on the left femoral neck region using X-ray absorptiometry Dual energy (DXA) unit g / cm^2.Age, height and weigh were recorded at the time of BMD measurement, and the body mass index (BMI) was calculated as (body weight to the nearest kilograms divided by the square of height in meters). T- and Z-score were derived from the manufactures database.

Table 1. participant Demographic and Anthropometric characteristics

participant characteristics	μ±SD
Age (years)	59.57 ± 14.21
Weight (kg)	67.75 ± 8.96
Height (m)	161.95 ± 6.27
BMI (kg/m^2)	25.88±3.57
Neck.BMD(g/cm^2)	0.80± 0.14
Lumber.BMD(g/cm^2)	0.93± 0.16

statistical analysis:

The statistical analysis was performed using the Package of (SPSS.16). An alpha level considered significant when the two-tailed p value was less than 005. Descriptive statistics were used to analyze characteristics of the participants .For purposes of analysis, prevalence of osteoporosis and obesity were computed and BMI was divided into quartiles (< 25 , 25-29 ,30-34, ≥35 kg/m^2).A regression analysis was used to explore the relation between BMD and risk factors for osteoporosis .

3. Results:

To fulfill the aim of the study two independent variables were studied versus two dependent variables such as the BMI and age versus LS. BMD and Neck.BMD, respectively.

3.1Descriptive statistical analysis results for the sample properties;

When measuring bone density using a device (DXA) in the study group and compare the results values peak among women and based on the definition of the World Health Organization and based on (T-score), we found that (20%) of the ladies bone density have within normal rates in the region of the lumbar spine and (29%) in the left femoral neck and (46%) have a osteopenia in bone density in the lumbar spine and (57%) in the left femoral neck and (34%) suffer from osteoporosis in the lumbar spine and (13%) in the area left femoral neck.

From the following table (2) we note that there is a significant positive correlation between bone mineral density in the lumbar spine and negatively associated with age. The bone mineral density in the femoral neck region has been negatively associated age. BMI was not a significant predictor of the bone mineral density in the femoral neck region.

Table 2: Person Correlation between bone mineral density, body mass index (BMI) and age:

**.correlation is significant at the 0.01 level (2-tailed).

*.correlation is significant at the 0.05 level (2-tailed).

	BMI	AGE
L.BMD	0.213**	-0.164*
T-score	0.195*	-0.153
Z-score	0.184*	0.244
N.BMD	0.092	-0.298**
T-score	0.086	-0.312**
Z-score	0.034	0.139

For more accurate results we divided the sample for age-groups of ten years.

Table3: BMD and BMI According to Age groups:

Age group	Percentage %	)LS.BMD( )µ±SD(	)N.BMD( )µ±SD(
21-30	3.3 %	0.914±0.135	0.857±0.157
31-40	8 %	0.967±0.102	0,833±0.125
41-50	14 %	0.994±0.183	0.874±0.189
51-60	21.3 %	0.929± 0,152	0.834±0.131
61-70	30 %	0.925± 0.154	0.791±0.104
71-80	16.7 %	0.855± 0.139	0.703±0.132
81-90	6.7 %	0.929±0.207	0.760±0.151

When we linked aging for each age-group with the bone mineral density in table (4) we note that age was not a significant predictor of the bone mineral density in the femoral neck and in lumber -spine region in each age-group.

Table (4)

Age group	$R_{Age/N.BMD}$	$R_{Age/L.BMD}$	$R_{BMI/L.BMD}$	$R_{BMI/N.BMD}$
21-30	0.109	0.186	0.248	0.075
31-40	0.336	0.196	-0.543	-0.344
41-50	0.360	0.405	0.442*	0.242
51-60	-0.118	0.002	0.288	0.405*
61-70	-0.245	-0.260	0.348*	0.072
71-80	-0.037	-0.024	0.039	-0.001
81-90	-0.270	-0.205	0.037	-0.016

Through the values of body mass index (BMI) we found that the proportion of obese women (12%), and overweight (40.7%), and women with normal weight (46.7%).

Table5: Age and BMD According to BMI

Property	)LS.BMD( )µ±SD(	)N.BMD( )µ±SD(	$R_{Age/L.BMD}$	$R_{Age/N.BMD}$	$R_{BMI/L.BMD}$	$R_{BMI/N.BMD}$
Normal	0.893±0.143	0.767±0.132	-0.176	-.0438**	0.134	0.076
Overweight	0.952±0.149	0,841±0.144	0.213-	-0.167	0.059	-0.050
Obesity	0.981±0.21	0.794±0.160	0.419-	0.554*-	-0.050	-0.269

From Table (5) we found that femoral neck BMD was higher in the overweight group, while the lumber spine BMD was higher in obesity group. The table value of r at the 0.05 level showed that the femoral neck BMD in the obesity and normal group highly negatively correlated with age.

Inferential statistical analysis results to test the hypotheses:

Null hypothesis testing concerning the impact of body mass and age on bone mineral density in the lumbar Spine and the femoral neck region. To test the main assumptions were adopted regression analysis of variance test to calculate the values of F that measure the possibility of an impact between each independent variable (Age and BMI) on the dependent variable (L.BMD and Neck.BMD) of the null hypothesis tested:

Null hypotheses:

H_o: $ß_1 = 0$, There is no statistically significant effect of the independent variable on the dependent variable at the level (0.05).

Alternatives hypotheses:

H_1: $ß_1 \neq 0$, there is statistically significant effect of the independent variable on the dependent variable at the level (0.05).

Decision rule is: If the F-statistics computed in the ANOVA table is less than the F-table statistics (or if the P-value is greater than the alpha level of significance), then there is not reason to reject the null hypothesis

The first hypothesis:

H_o: There is no statistically significant of the body mass (BMI) on bone mineral density in the lumbar region (L.BMD)

To test the validity of the hypothesis previous test was used linear regression to find the regression coefficient between the independent variable (BMI) and the dependent variable (L.BMD) the results of the following tables show that:

Table (6)

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.169	1	.169	7.040	.009[a]
	Residual	3.554	148	.024		
	Total	3.723	149			

a. Predictors: (Constant), BMI

b. Dependent Variable: LumberB.M.D

from Table(6) the level of significance is lower than the level (0.05) Therefore, we accept the alternatives hypotheses H_1, and say that body mass effect bone mineral density in the lumbar region (L-B.M.D)

The second hypothesis:

H_o There is no statistically significant effect of the body mass on bone mineral density in the femoral neck region at the level (0.05).

Table (7)

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.026	1	.026	1.253	.265[a]
	Residual	3.045	148	.021		
	Total	3.071	149			

a. Predictors: (Constant), BMI

b. Dependent Variable: NeckB.M.D

P = 26.5% more than α = 5 % , then we then we accept the null hypotheses H_0, which means that the body mass did not effect bone mineral density in the femoral neck region (N-B.M.D)

Third hypothesis:

H_o There is no statistically significant effect of age on bone mineral density in the lumbar spine

Table (8)

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.101	1	.101	4.109	.044[a]
	Residual	3.622	148	.024		
	Total	3.723	149			

a. Predictors: (Constant), Age

b. Dependent Variable: LumberB.M.D

P = 4.4% less than α = 5 %, then we accept the alternatives hypotheses H_1, This means that the age effect bone mineral density in the lumbar region (L-B.M.D).

Fourth hypothesis:

H_o: There is no statistically significant effect of age on bone mineral density in the femoral neck region

Table (9)

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.273	1	.273	14.462	.000[a]
	Residual	2.798	148	.019		
	Total	3.071	149			

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.273	1	.273	14.462	.000[a]
	Residual	2.798	148	.019		
	Total	3.071	149			

a. Predictors: (Constant), Age

b. Dependent Variable: NeckB.M.D

P = 0 % less than α = 5 %, so we accept the alternatives hypotheses H_1, This means that the age affect bone mineral density in the femoral neck region (N-B.M.D)

Estimate regression equations:

1) Regression equation of bone mineral density in the lumber spine(y) on body mass (x)

Table (10)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.684	.093		7.363	.000
	BMI	.009	.004	.213	2.653	.009

a. Dependent Variable: LumberB.M.D

It is clear from the above table (10) that: The linear correlation factor: R= 0.213, t = 2.653.

The linear regression equation: Y = 0.684+0.009x

2) Regression equation of bone mineral density in the femoral neck(y) on body mass (x)

Table (11)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.706	.086		8.213	.000
	BMI	.004	.003	.092	1.119	.265

a. Dependent Variable: NeckB.M.D

The linear correlation coefficient: R= 0.092, t = 1.119

The linear regression equation: Y = 0.706+0.004x

3) Regression equation of bone mineral density in the lumber spine(y) on age(x)

Table (12)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.036	.055		18.774	.000
	Age	-.002-	.001	-.164-	-2.027-	.044

a. Dependent Variable: LumberB.M.D

The linear correlation coefficient: R= -0.164, t = -2.027

The linear regression equation: Y = 1.036-0.002x

4) Regression equation of bone mineral density in the femoral neck(y) on age (x)

Table (13)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.981	.049		20.210	.000
	Age	-.003-	.001	-.298-	-3.803-	.000

a. Dependent Variable: NeckB.M.D

The linear correlation coefficient: $R= -0.298$, $t = -3.803$

The linear regression equation: $Y = 0.981-0.003x$

Conclusions:

We conclude that the average bone mineral density of normal Jordanian women's is approximately (0.893 ± 0.143) in lumber spine and (0.767 ± 0.132) in femoral neck .

In this group of females, bone mineral density in the lumbar spine was primarily influenced by age and BMI while bone mineral density in the femoral neck was primarily influenced by age only.

The comparison of BMD and BMI in groups of (overweight, normal weight and obesity) indicates that the high BMD associated with obesity results. The results of BMD according age- groups indicate that the high BMD associated with (41-50) years.

T-test one sample test gave a good significant of 0.000 for BMD versus the age <0.05.Finally, ANOVA Test for age and BMI versus BMD are shown by demonstrating: sum of squares, degree of freedom, mean square, and significance.

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