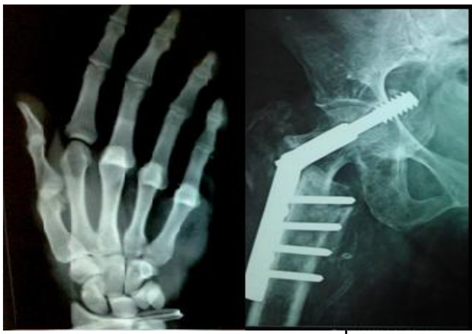

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Is high bone mass index protective for osteoporosis? ‘Evaluation of relationship between body mass index, and bone mineral density in the population of the Himalayan region of India

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Abstract
Objective: Although several studies have done for relationship between obesity and bone mineral density (BMD), the results are inconclusive. The aim of this study was to further investigate the relation between age, weight, BMI and BMD in outpatients of Himalayan region.
Materials and methods: A hospital based cross sectional study was conducted on patients attending the outpatient Department of Orthopaedics of Shri Mahant Indiresh Hospital for a period of 3 years from September 2014 to September 2017. A total no. of 232 patients (198 F+ 34M) in the age group of 30 - 90 years were selected randomly for the study. Exclusion criteria were age less than 30 and more than 90 years, confirmed cases of osteoporosis, patients on antiresorptive treatment, cases of surgically removed ovary and uterus, bone metastasis. Dual Energy X-ray Absorptiometry (DXA) scans were obtained to assess presence of low BMD. BMI calculations and BMD T-Score at femoral neck were done in all patients. Participants were categorized in BMI group (underweight <18.5 kg/m^2, normal weight ≤25.0 kg/m^2, overweight BMI ≥ 25 kg/m^2 and obese ≥ 30 kg/m$^{2.}$) and BMD groups (normal < -1, osteopenia -1 to < -2.5, osteoporosis ≥ -2.5 and severe osteoporosis > -3). Statistical Package for Social Sciences (SPSS) version 20 was used for statistical analysis.
Results: Subjects with higher Bone Mass Index were having high bone mineral density and less prone for osteoporosis. It was also evident that subjects in the higher age group were more prone of having osteoporosis. So it can be concluded that Body Mass Index and BMD showed a positive correlation, whereas, advancing age is associated with low BMD.

Keywords: BMI, BMD, osteoporosis, osteopenia, DEXA

1. Introduction

Bone strength has a great value for any individual, weakening of bones is never a welcome change in the body, this not only leads to many more problems, but is well associated with incidence of bone fractures and various other diseases, disabilities, deformities, having direct effects with the quality of life and even future remaining period of life span in any individual.
Most of the times doctors take care of diseases which are obvious and may require immediate attention, therefore in this form of management basic cause that lies behind the disease is not given proper attentions and result is that basic cause behind the disease process remain unattended and uncared for. This approach is not a total care but, partial management only.
Bone is not an static structure in our body, structure and composition of bony tissue remains ever changing inside a human body throughout the life span, this has been well observed in medical literatures that with advancing age bones become weak to weaker, but why, what can we do for it, can this process of weakening of bones can be assessed at appropriate time, can it be known early so that proper care and treatment may be given in time not only to prevent the diseases caused by weak bones, but to prevent the future fractures in these weak bones, well in time which will improve all ill effects of those injuries, including effect on the style and span of life in any individual.

With these queries in our mind we inspired to study that whether body weight and BODY MASS INDEX (BMI), is having any correlation with bone strength which can be measured by the assessment of BONE MINIRAL DENSITY (BMD) and how this can be helpful to prevent future fracture cases specially in weak bones with advancing age and what can be done for betterment of bone health, in such cases.

2. Materials and methods
2.1 Study design
A hospital based random cross sectional study was conducted on patients attending the Outpatient dept of Orthopaedics of Shri Mahant Indiresh Hospital, Shri Guru Ram Rai Institute of Medical and Health Sciences for a period of 3 years from September 2014 to September 2017. A total number of 232 patients in the age group 33 to 90 years, of both sexes were screened for the study who visited OPD for various orthopaedics problems. We excluded confirmed cases of osteoporosis, patients on antiresorptive treatment, cases of surgically removed ovary and uterus, bone metastasis.

2.2 Measurements
2.2.1BMD measurement
BMD is the main criteria used to diagnose and monitor osteoporosis. DEXA is the current gold standard examination of osteoporosis in male and female, which is used to examine the bone mass of total hip, femoral neck, lumbar spine, or whole body. Hip DEXA were obtained using the lunar DPX DXA system analysis version 13.6 (manufactured by GE healthcare). The purpose of bone mass measurement are to determine diagnosis of osteoporosis, to predict the occurrence of fractures, to assess changes in bone density after treatment. In this study, position of patients were in femoral neck. Measurement of bone density usually expressed in T-scores, where the standard deviations number of bone density varies from the average bone density in normal subjects with the same sex. WHO define osteoporosis as a condition in which bone mineral density is below -2.5 SD, osteopenia in which bone mineral density between -1 to -2.5 SD, while normal in which bone mineral density is above -1 SD [1].

2.2.2 Measurement of height, weight and BMI
Height and weight were recorded for all patients. Informed written consent has been taken from all participants. BMI was calculated as weight in pounds divided by the square of height in inches multiply by 703. Height was measured using a wall mount scale in inches and Body weight was measured using a digital weight scales in pounds. Bone Mass Index obtained by using the formula (weight in pounds/ height in inches^2 x 703).

2.3 Statistical Analysis
SPSS (version 20, IBM SPSS statistics for windows) was used for analysis of and all data. Descriptive statistics were used to report mean, standard deviation, percentage, median and range. After running the normality test on data, the results of each examination were counted, and the correlations among each examinations were evaluated using Pearsman's correlation test. The participants were divided based on gender and further subdivided into osteoporosis, osteopenia and normal groups. In each group, a regression analysis was conducted between each variable (age, BMI, height, and weight) and T-scores. In each regression analysis, the correlation between variables was significant if the P-value was less than 0.05. ANOVA test was applied for comparison of means between and with groups for both BMD grading groups and BMI (obesity) grading groups. Post hoc HSD was applied for multiple comparison.

3. Results
This study was conducted on 232 subjects (198 female and 34 male subjects) who had DXA hip (femoral neck DEXA obtained using the lunar DPX DXA system analysis version 13.6 manufactured by GE healthcare) images taken between September 2014 and September 2017. All subjects provided written informed consent prior to participation.

Total 232 subjects with mean age of 58.01±11.68 (range 33 to 90 years) were consisted of 34 (14.7%) males (M) and 198 (85.3%) females (F). Mean BMD T score at the femoral neck was -1.53±1.4 (table no.1).

According to femoral neck BMD T- score 31 (13.4%) subjects (6 M, 25 F) had severe osteoporosis; 22 (9.5%) subjects, (3 M, 19 F) had osteoporosis; 97 (41.8%) subjects (13 M, 84 F) had osteopenia and 82 (35.3%) subjects (12M, 70F) had normal BMD T- Score (figure no.2).

There were 6 (2.6%) subjects (6F, 0 M) in underweight group, 116 (50%) subjects (97F, 19M) in normal weight group, 71(30.6%) subjects (60F, 11M) in overweight group and 39 (16.8%) subjects (35F, 4M) in obese group. 50% subjects in this study were in normal weight (fig no. 3)

Table 1: Demographic data of the participants

Variables	Mean ± Sd	Median (Range)
FEMALE (N = 198)		
Age (In Years)	56.78 ±11.11	56.50 (34 -90)
Bmi	25.75 ± 4.98	24.89 (14 – 46.91)
Height (Inches)	61.17 ± 3.1	61 (39 – 71)
Weight (Pounds)	136.72 ± 26.59	134 (71 – 220)
Bmd T-Score (Femoral Neck)	-1.51 ± 1.32	-2.00 (-6 TO 3)
MALE (N- 34)		
Age (In Years)	65.15 ± 12.53	66.50 (39 -90)
Bmi	25.21 ± 3.92	24.24 (18.51 – 34.10)
Height (Inches)	64.50 ± 3.018	65(59 – 71)
Weight (Pounds)	148.85 ± 21.71	148 (110– 209)
Bmd T-Score (Femoral Neck)	-1.61 ± 1.84	-2.00 (-8 TO 1)
Total (N- 232)		
Age (In Years)	58.01±11.68	58 (34 -90)
Bmi	25.66 ± 4.84	24 (46-14.6)
Height (Inches)	61.66 ± 3.3	61 (39 -71)
Weight (Pound)	138 ± 26.24	137 71- 220)
Bmd T- Score(Femoral Neck)	-1.53 ± 1.41	-2.0 (3 to -8)

SD, standard deviation; BMI, body mass index; BMD, bone mineral density.

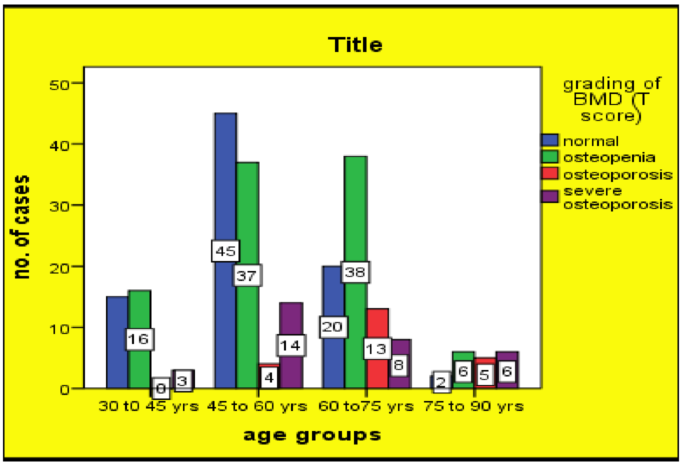


Fig 1: distribution of subjects according to age group and bmd grading

Age groups (yrs)	Grading of BMD			
	normal	**osteopenia**	**osteoporosis**	**Severe osteoporosis**
30 – 45	15	16	0	3
45- 60	45	37	4	14
60 - 75	20	38	13	8
75 – 90	2	6	5	6
total	82	97	22	31

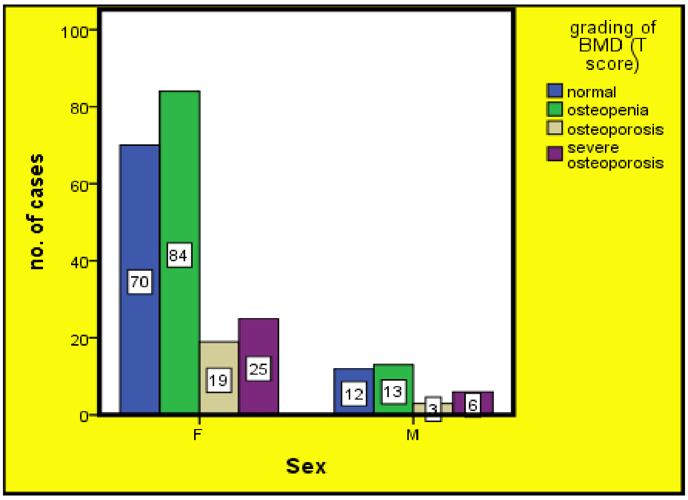


Fig 2: depicts sex wise distribution of cases according to bmd grading

	Grading of BMD					
sex	**normal**	**osteopenia**	**osteoporosis**	**Severe osteoporosis**	**total**	**%**
female	70	84	19	25	198	85.34
male	12	13	3	6	34	14.65
total	82	97	22	31	232	100%

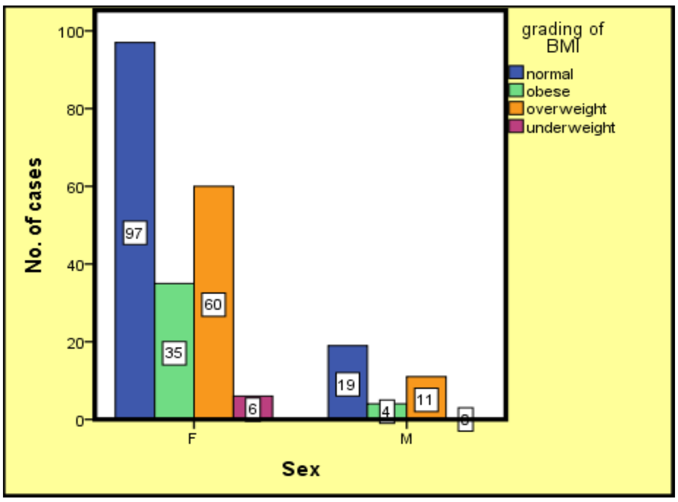


Fig 3: depicts sex wise distribution according to bmi (obesity) grading.

BMI grading	Female	Male	total	%
underweight	6	0	6	2.59
normal	97	19	116	50
overweight	60	11	71	30.6
obese	35	4	39	16.81

Table 2: Depicts Pearson's Correlation In Variables

Correlation of Variables		Pearson Correlation 'r'	Significance(2 –tailed)	Results
Age	weight	-0.068	0.31	NS
	height	-0.082	0.214	NS
	BMI	-0.012	0.068	NS
	BMD T- score	-0.28	0.001	SS
Weight	height	0.354	0.001	SS
	BMI	0.81	0.001	SS
	BMD T score	0.35	0.001	SS
Height	BMI	-0.25	0.001	SS
	BMD T score	0.080	0.23	NS
BMI	BMD T score	0.303	0.001	SS

Pearson's correlation analysis shown in table no.2 reveals a statistically significant negative correlation between age and BMD T-score in femur neck (r = 0.028, p<0.001) [figure 4] but no significant correlation with weight, height and BMI. Statistically Significant positive correlation of weight with height, BMI and BMD T-score at femoral neck (r = 0.354, p<0.001; r=0.81, p<0.001; r = .346, p<0.001recepectivily) [figure 4, 6, 7]. A significant negative correlation between height and BMI (r = -0.25, p<0.001) but no significant correlation between height and BMD T-score at femoral Neck (r = 0.080, p>0.223) present. A statistically significant positive correlation was shown between BMI and BMD T-score at femoral neck(r = 0.303, p<0.001) [figure 4].

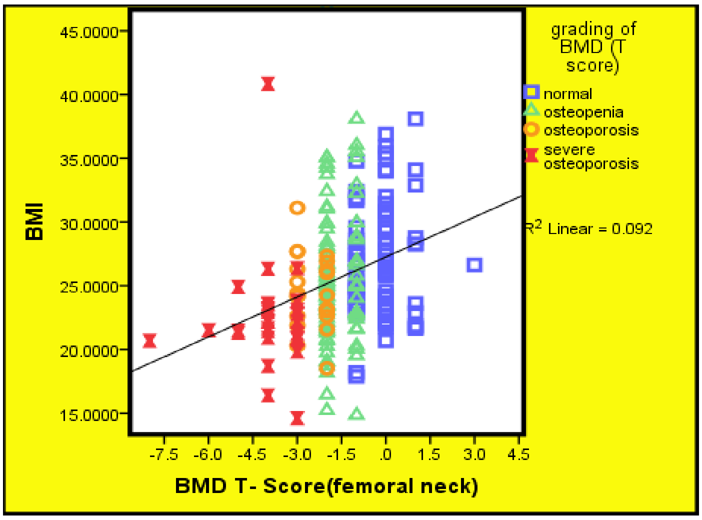


Fig 4: Scatter diagram showing positive correlation of bmd t- score and bmi, that means high body mass index associated with high bone mass density (t- score)

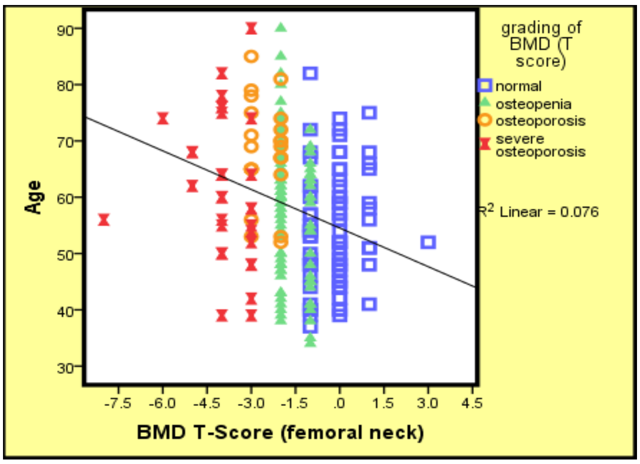


Fig 5: Scatter diagram showing strongly negative correlation of bmd and age that means bone mass density decreases with increasing age.

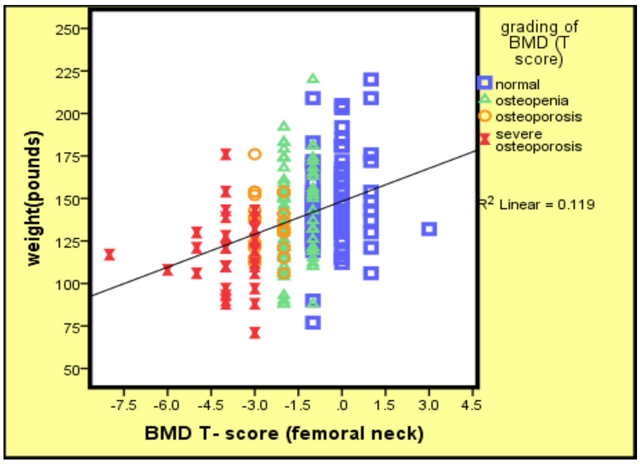


Fig 6: Scatter diagram showing weak positive correlation between bmd and weight.

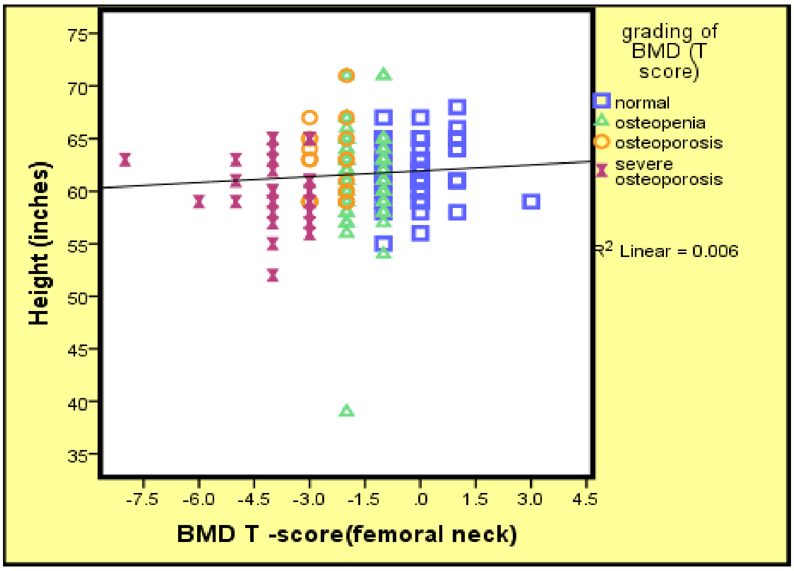


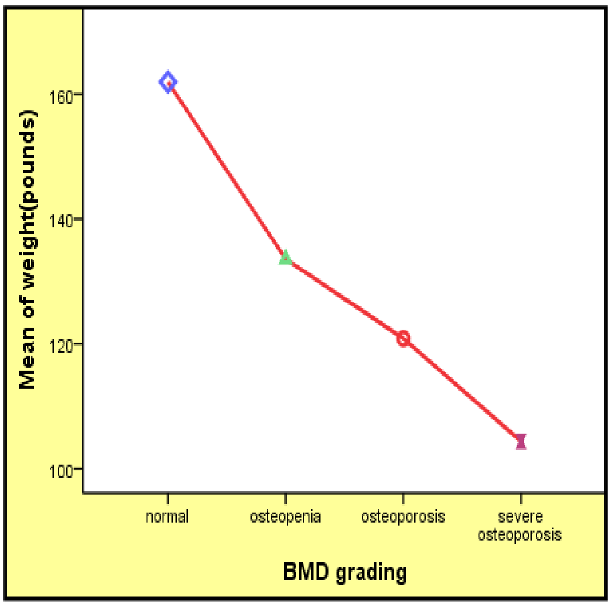
Fig 7: Scatter diagram showing no correlation between bmd and height

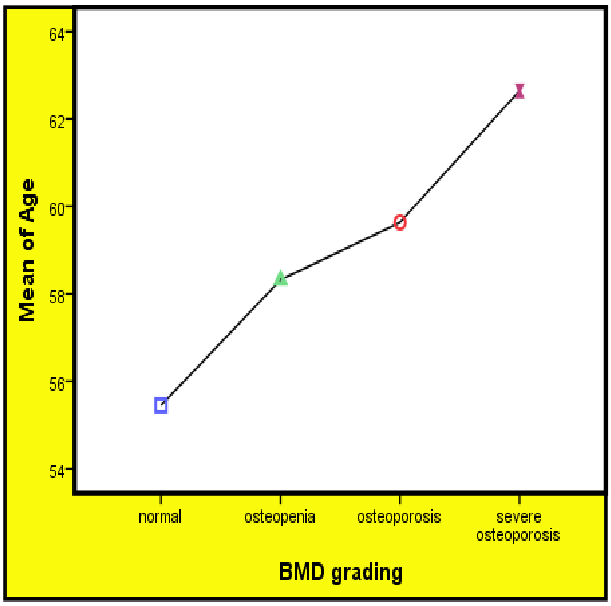
A one way between groups analysis of variance was conducted to explore the impact of age, weight, height and BMI on BMD Grading (bone mass). Participant were divided into four groups according to BMD T-score at femoral neck (normal= <-1, osteopenia= -1 to -2.5, osteoporosis = >-2.5 and severe osteoporosis >-3.0). There were statistically significant difference of means of Age, weight and BMI for four groups of BMD (age F 3. 1, *p*<.024; weight F 99.84, *p*<0.0001; BMI F 213.4, P, 0.0001), but there was no statistically difference in mean of height between groups.

Table 3: Anova

WHO BMD grading		df	Mean Square	F	Sig.	results
Weight (pounds)	Between Groups	3	30121.526	99.842	0.000	SS
	Within Groups	228	301.690			
	Total	231				
Height (inches)	Between Groups	3	28.781	2.700	0.055	NS
	Within Groups	228	10.658			
	Total	231				
bmi	Between Groups	3	1329.875	213.406	0.000	SS
	Within Groups	228	6.232			
	Total	231				
Age	Between Groups	3	423.466	3.190	0.024	S
	Within Groups	228	132.744			
	Total	231				

Correlation is significant at p value of <.05





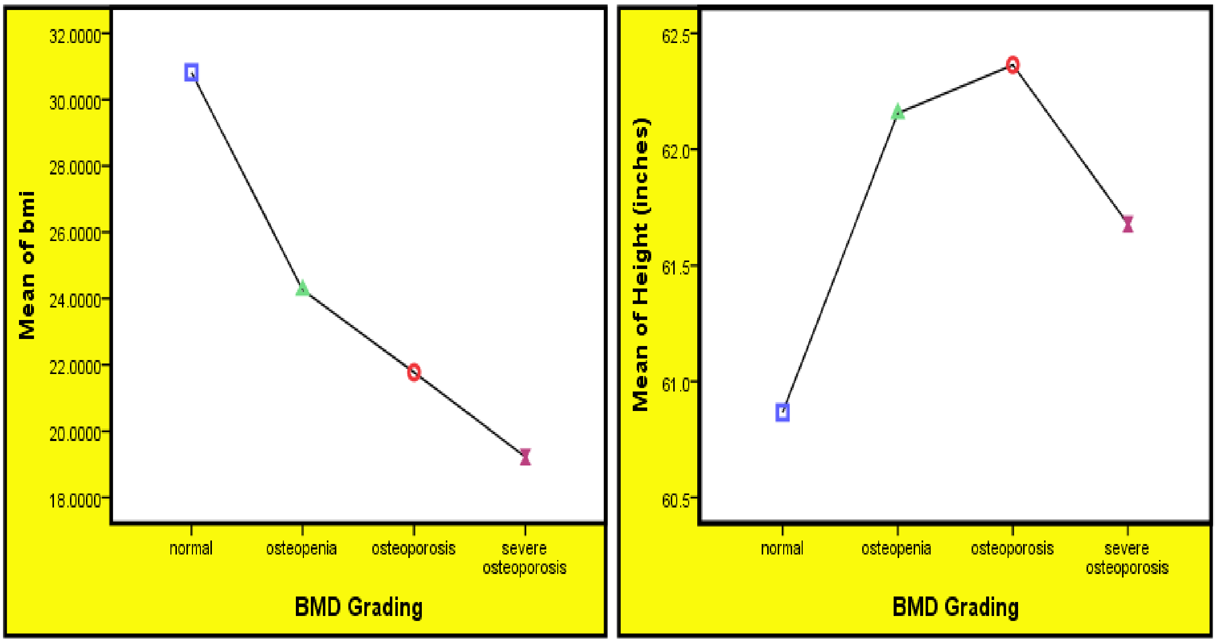


Fig 8: Mean plots diagram showing liner association of means of age, weight, and bmi with bmd grading.

One way Anova was also conducted to explore the impact of BMI on T-score (bone mass). Participant were divided into four groups according to BMI (Underweight <18.5 BMI, normal between 18.5 to 25, overweight between 25 to 30 and obese >30 BMI). There was statistically significant difference at the $p<0.0001$ level in T- Scores (bone Mass) for obesity grading groups F 8.476, $P<0.0001$ (table no.5). Post comparisons using the Tukey HSD test indicated that mean of T- Score for normal BMI (-1.91±1.5) was significantly different from overweight (-1.23± 1.16) and obese (-0.82± 1.12) but there was no statistically significant difference in mean score between normal and underweight ($p<0.97$) (table no. 6).

Table 5: Anova

T score(femoral neck)						
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**result**
Between Groups	45.736	3	15.245	8.476	.0001	SS
Within Groups	410.109	228	1.799			
Total	455.845	231				

Table 4: Descriptives Analysis

T score(femoral neck)								
BMI grading (kg/metre^2)	**N**	**Mean**	**SD**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
underweight	6	-2.17	1.169	.477	-3.39	-.94	-4	-1
normal	116	-1.91	1.507	.140	-2.19	-1.64	-8	1
overweight	71	-1.23	1.161	.138	-1.50	-.95	-4	3
obese	39	-.82	1.121	.179	-1.18	-.46	-4	1
Total	232	-1.53	1.405	.092	-1.71	-1.34	-8	3

Table 6: Multiple Comparisons

Dependent Variable: T score(femoral neck) Tukey HSD						
(I) grading of BMI	**(J) grading of BMI**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
underweight	normal	-.253	.562	.970	-1.71	1.20
	overweight	-.941	.570	.352	-2.42	.53
	obese	-1.346	.588	.104	-2.87	.18
normal	underweight	.253	.562	.970	-1.20	1.71
	overweight	-.688*	.202	.004	-1.21	-.17
	obese	-1.093*	.248	.000	-1.74	-.45
overweight	underweight	.941	.570	.352	-.53	2.42
	normal	.688*	.202	.004	.17	1.21
	obese	-.405	.267	.430	-1.10	.29
obese	underweight	1.346	.588	.104	-.18	2.87
	normal	1.093*	.248	.000	.45	1.74
	overweight	.405	.267	.430	-.29	1.10
*. The mean difference is significant at the 0.05 level.						

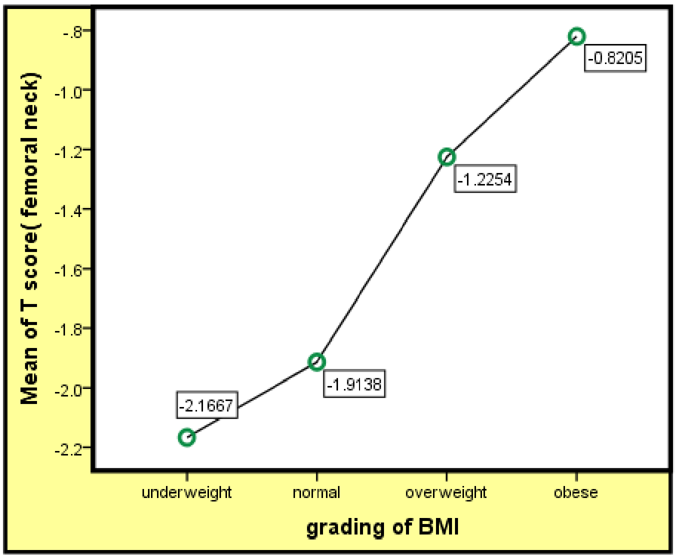


Fig 7: Diagram showing liner positive association between grading of bmi and mean of t- score.

4. Discussion

Osteoporosis is a silent disease which progress inside the human body without even producing any much symptoms, leading to gradual weakening of bones which predisposes to future fractures. The present study shows low BMI individuals lose more bone compared to those with higher BMI individuals (Figure 4, 7). Studies conducted by Ravn *et al* and Bjarnason and Christiansen indicates that early postmenopausal women who have low BMI lose more bone compared to those with higher BMI women [2, 3]. Studies conducted by Van der Voort *et al* found that thinning of bone is related to both osteoporosis and increased fracture risk [4, 5] Hence, low BMI was included in the risk assessment tools for evaluation of osteoporosis and osteoporotic fracture risk as suggested by Eddy *et al* and National Osteoporosis Foundation by Black *et al* [6].

Obesity and osteoporosis are two important and growing public health problems worldwide [7-9], and osteoporotic fractures are among them in concerns of elderly population. Low bone mineral density (BMD) is a major risk factor for osteoporosis and its related fractures. Relationship between body mass index (BMI), weight, height, and BMD was reported for many populations [10-12]. Body weight or BMI has been found to be inversely related to the risk of osteoporotic fracture [13, 14]. The present study was conducted in Uttarakhand, India to identify the factors associated with the incidence of low BMD. The two main factors considered included age and BMI. The Studies of National Osteoporosis Foundation and others suggested that low BMI should be included in the risk Assessment tools for evaluation of osteoporosis and osteoporotic fracture risk [15, 16]. In the review literatures Baheiraei *et al.* [17], Jones *et al.* [18], and Nguyen *et al.* [19] indicated that advancing age was associated with low BMD, In their studies, we also observed an association between age and bone mineral density. The chance of low bone mineral density among the people with age 60 and above is higher compared to those with age <45 years [fig no 1].

Iqbal *et al.* [20] found that low BMI is a good indicator for referral of women less than 60 years old for measurements of BMD.

Underweight and normal female and male were more likely to have osteoporosis and osteopenia. Similar studies by Nguyen *et al.* [19] and Baheiraei *et al.* [17] reported the consistent finding that lower BMI was associated with lower BMD. The mechanisms whereby adipose tissue exerts positive effects on BMD status are not entirely clear. The putative mechanism relevance of adipose tissue for skeletal integrity probably resides in the role of several adipokines in bone remodeling through effect on both formation and resorption.

Recently, bone has been considered an endocrine organ affecting body weight control and glucose homoeostasis through the actions of bone-derived factors such as osteocalcin and osteopontin [21-24].

5. Conclusion

From the above study we can conclude that BMI and BMD show a positive correlation, whereas, advancing age is associated with low BMD. Lower BMI is an important risk factor for the occurrence of low BMD. Overweight and obesity decreased the risk for osteoporosis. Efforts are needed for prevention of osteoporosis in elderly men as well as postmenopausal women with low BMI and this may help reduce fractures among ageing population and its associated morbidity and mortality. In order to prevent the risk of osteoporosis, patients should be advised to maintain a normal weight. Exercise prescription helps to maintain the BMD in all ages.

6. Conflict of Interests: The authors declare no conflict of interests.

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