Nāsadīyam
A Multi-Disciplinary National Research Journal (Annual)
Peer Reviewed/Refereed
Available online at: https://nasadiyam.dmmkkr.ac.in/
Issue 1, Jan – Dec. 2022, Pp 50-57

Evaluation of The Relationship between Bone Mineral Density and Body Mass Index

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ABSTRACT:

Osteoporosis and Obesity are the two life style related diseases. Osteoporosis is a progressive disease which is characterized by the abnormal loss of bone density. It leads to bone fragility and can increase the susceptibility to fractures. It can be assessed by using Bone Mineral Density (BMD). A person becomes obese, when during a particular period of time his energy intake is more than the energy expenditure. Obesity is commonly assessed by using Body Mass Index (BMI). BMI and BMD are influenced by lifestyle factors such as diet, physical activity, and hormonal levels. Numerous studies suggested that BMD and BMI are positively correlated. In contrast, recent studies also highlighted that the high BMI is inversely related with BMD and the formation of bones. This study evaluates the relation between BMD and BMI, which were the diagnostic criteria for osteoporosis and obesity respectively. A total of hundred subjects were studied under the present study. Subjects were selected on random basis residing in district Kurukshetra who were routine visitors of Sahay's Clinic. Anthropometric dimensions of the subjects were calculated by standard method. The Bone Density-T score of the subjects was measured with Quantitative Ultrasound Procedure by Technical Experts with Omnisense 8000 S device (Sunlight Medical, Ltd., Rehovot, Israel). Interestingly 68 per cent of the subjects showed a normal BMD (83±.55), 18 per cent of women showed a BMD T-score-1.83±.28 (osteopenic) and 14 per cent were osteoporotic with BMD T-score of -2.68±.17. When the population was divided into subgroups based on different BMI(Osteoporosis category), it was noticed that maximum low Bone Mineral Density was found in Obese Grade – II (50 per cent) followed by Obese Grade – I (28.57 per cent) and Normal (21.42 per cent) subjects respectively. Maximum osteopenia was found in normal subjects (55.5 percent)

followed by Obese Grade – II (27.7 per cent) and Obese Grade – I (16.6 per cent) respectively.

Results obtained from Pearson correlation coefficient showed that there is non-significant and very small positive relationship between BMI and BMD. More future researches should continue to explore the mechanisms driving these associations, particularly in diverse population, and develop strategies to optimize both body weight and bone health are also required.

Keywords: Bone Mineral Density (BMD), Body Mass Index (BMI), Obesity, Osteopenia, Osteoporosis

INTRODUCTION:

Osteoporosis and Obesity are the two life style related diseases. Osteoporosis is a progressive disease which is characterized by the abnormal loss of bone density. It leads to bone fragility and can increase the susceptibility to fractures. It can be assessed by using Bone Mineral Density (BMD), which measures the amount of mineral content in bones. BMD test is usually reported in T-Score, which compares the patient's bone density 2.5 standard deviations or more below the average peak bone mass to that of a healthy young adult of the same age. Low BMD (Bone Mineral Density) is associated with an increased risk of osteoporosis and fractures, particularly in postmenopausal women and elderly individuals (WHO, 2007)[1].

When during a particular period of time the energy intake is more than the energy expenditure, it will result in obesity. Obesity is commonly assessed by using Body Mass Index (BMI). It is calculated by dividing the person's weight (in kg) by the square of their height (in m.) and its categories are typically divided into four parameters i.e. underweight if BMI<18.5 kg/m^2, normal weight if BMI is between 18.5-24.9kg/m^2, overweight if BMI is between 25-29.9kg/m^2, and obese if BMI $\geq$30kg/m^2. BMI (Body Mass Index) is a useful indicator to analyze body fat and overall health risk (WHO, 2024)[2]. Both BMI and BMD are influenced by lifestyle factors such as diet, physical activity, and hormonal levels.

Numerous studies suggested that BMD and BMI are positively correlated. Higher body weight increases the load on bones especially on the bones which carry weight such as the spine and femur and it leads to increased bone formation and mineralization. Further, bone metabolism may also be influenced by hormones and cytokines (adipokines) is produced

by adipose tissue, especially visceral fat. These factors generally suggest that higher BMI could be protective against bone loss (Zha et al., 2015)[3]. However, BMI does not provide information on fat distribution; it is often used to assess obesity. It is well established that the location of body fat specifically of visceral versus subcutaneous fat plays a critical role in determining health outcomes (Rayan et al., 2003)[4].

In contrast, recent studies highlighted that higher level of BMI is inversely related with BMD and formation of bones (Cohens et al., 2013)[5]. Studies have suggested that, unlike subcutaneous fat, visceral fat may secrete pro-inflammatory cytokines like tumor necrosis factor-alpha (TNF-α) and interleukins which increase osteoclast activity, promoting bone resorption. These inflammatory markers may inhibit osteoblast function and bone formation, leading to a reduction in BMD (Rayan et al., 2003)[4].

However, very few studies relate these two life style diseases with each other which are again contradictory to each other. Keeping, both the contrasting above facts in view, the present study was undertaken to check relation between Bone Mineral Density (BMD) and Body Mass Index (BMI) which were the diagnostic criteria for osteoporosis and obesity respectively.

METHODOLOGY

A total of hundred subjects were studied under the present study. Subjects were selected on random basis who were routine visitors of the Sahay's Clinic. The subjects were fully informed about the purpose as well as the procedure of the investigation and provided consent at the outset. Anthropometric dimensions of the subjects were calculated by standard method.

Instrument

The Bone Density-T score of the subjects was measured with Quantitative Ultrasound Procedure by Technical Experts with Omnisense 8000 S device (Sunlight Medical, Ltd., Rehovot, Israel).

Statistical Analysis

The results were analyzed using percentage, arithmetic mean, standard deviation and Pearson Correlation.

RESULTS & DISCUSSION

Demographic Profile: The present investigations were carried out on women residing in district Kurukshetra (Haryana) and are routine visitors of Dr. Sahay's Clinic. Table 1 reveals mean height of studied subjects was 1.54±2.4m and weight was 60.9±9.31kg respectively. According to the present height and weight of studied subjects, their calculated mean BMI was 25.75±3.72kg/m.^{2}

Table 1: Mean (±S.D) Anthropometric Dimensions of Selected Subjects

Anthropometric Dimension	**Mean (± S.D)**
Age	37.85±7.85
Height (meters)	1.54±2.4
Weight (Kg)	60.9±9.31
BMI (Kg/m^2)	25.75±3.72

Table 2 depicts the categorization of the subjects based on their individual BMI's as proposed by ICMR (2005), showed that 3 per cent of the subjects had BMI 18.5 – 20.0kg/m^2 and were Low Weight Normal. Forty-four per cent of the subjects had BMI 20.0 – 25.0kg/m^2 and were in Normal category. The percentage of Grade I Obese and Grade II Obese in the studied subjects was 36 and 17 per cent with BMI 25.0 – 30kg/m^2 and > 30kg/m^2 respectively.

Table 2: Nutritional status categorization of the Selected Subjects(N=100)

BMI(Kg/m^2)	***Classification**	**Number (n)**	**Per cent (n/N×100)**
18.5 – 20.0	Low Weight Normal	3	3
20.0 – 25.0	Normal	44	44
25.0 - 30	Obese Grade –I	36	36
> 30.0	Obese Grade – II	17	17

***Source: ICMR (2005)**

Bone Mineral Density vs. diagnosis (WHO Criteria) of the selected subject is depicted in Table 3 which reveals that 68 per cent of the studied subjects were normal and had BMD-T score .83±.55. Osteopenia and Osteoporosis were found in 18 and 14 per cent of the subjects with BMD-T score -1.83±.28 and -2.68±.17 respectively. A study by Rizolli et al., (2017)[7] examining BMI and BMD in postmenopausal women found that increased BMI, especially in those with higher fat mass, could be associated with reduced bone density at certain sites, potentially due to hormonal changes, such as increased estrogen or inflammatory cytokines released by adipose tissue.

A study in middle-aged women done by Nguyen et al., (2001)[8] suggests that fat distribution play more important role in the bone health than BMI alone. As the total body fat mass is positively correlated with BMI, it is negatively correlated with BMD at certain skeletal sites (e.g., spine).

Table 3: Bone Mineral Density Vs Diagnosis of Selected Subjects (N=100)

BMD-T score	Diagnosis*	Total number of subjects having corresponding BMD T- scores (n)	Mean BMD-T score of the subjects	Percentage (n/N×100)
≥ -1	Normal	68	.83±.55	68
-1 to -2.49	Osteopenia	18	-1.83±.28	18
≥ -2.5	Osteoporosis	14	-2.68±.17	14

***WHO Criteria**

Figure 1: Bone Mineral Density of the Subjects

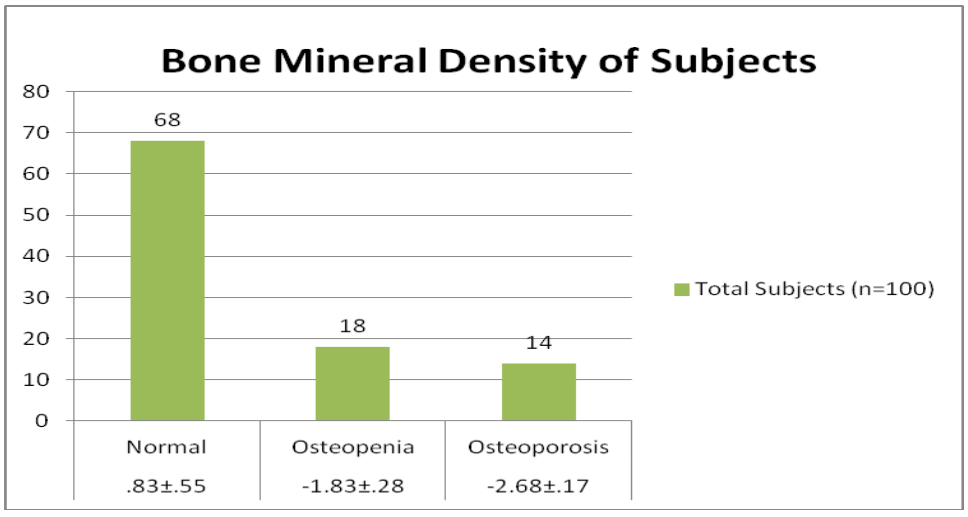


Table 4 reveals that 68 per cent of subjects are having normal BMD T-scores with different categories of BMI. Out of the hundred subjects' osteopenia is found in 10 subjects having normal BMI 20.0-25.0 Kg/m^2 followed by 3 and 5 subjects had BMI (Kg/m^2) 25.0-30 (Obese Grade I) and > 30.0 (Obese Grade II) respectively. Among the studied subject, osteoporosis was found in 7 subjects of Grade II obese category, which is followed by 4 subjects all of Grade I Obesity and 3 subjects of Normal BMI range respectively. Further it was concluded that Maximum low Bone Mineral Density (Osteoporosis) was found in Obese Grade – II (50 per cent) and it is followed by Obese Grade – I (28.57 per cent) and Normal (21.42 per cent) subjects respectively. Maximum osteopenia was found in Normal BMI category i.e. 55.5 percent of the subjects is followed by Obese Grade – II (27.7 per cent) and Obese Grade – I (16.6 per cent) respectively. Results obtained from Pearson Correlation coefficient indicate that there is non-significant and very small positive relation between BMI and BMD with *p* value $\leq$.540).

According to Bansal et al.,(2017)[9], Obesity does not have any protective role in the development of Osteoporosis. They suggested if we want to study about the role and effect of obesity on BMD then we have to study about molecular and cellular level in detail. Dore et al.,(2013)[9] also revealed that obesity may be linked to lower bone quality and there is negative relationship with BMD especially in elderly population. Higher BMI can lead to changes in bone structure, with an imbalance between bone formation and resorption, especially in individuals with a higher proportion of fat mass rather than muscle mass.

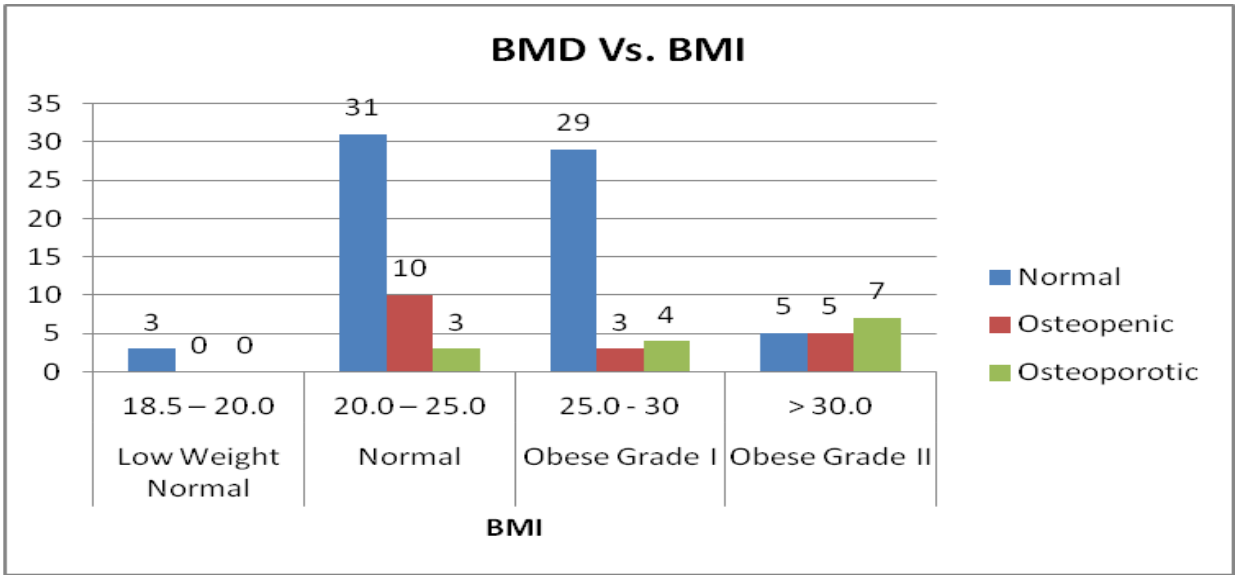
Table 4: Relation between BMD and BMI of the Body (N=100)

Bone Mineral Density (T-Score)	**Body Mass Index (Kg/m^2)**						**r value***
	Low Weight Normal	**Normal**	**Obese Grade I**	**Obese Grade II**	**Total (n)**	**Percentage (n/N×100)**	
	18.5 – 20.0	**20.0 – 25.0**	**25.0 - 30**	**> 30.0**			
Normal	3	31	29	5	68	68	**0.062**
Osteopenia	-	10	3	5	18	18	

Osteoporotic	-	3	4	7	14	14	
Total	**3**	**44**	**36**	**17**	**100**	**100**	

*P- value ≤ 0.54

Figure 1: Relation between BMD and BMI of the Body



CONCLUSION

Relationship between BMI and BMD is complex and multifactorial. While a higher BMI often correlates with higher BMD due to mechanical load and hormonal factors, this relationship is not always protective against fractures, particularly in population with visceral fat accumulation or especially in elderly individuals. Similarly, low BMI is related with low BMD and increased risk of fracture, especially in the underweight individuals or those with nutritional deficiencies. More future research should continue to explore the mechanisms driving these associations, particularly in diverse population, and develop strategies to optimize both body weight and bone health.

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