

Association of Saturation of Body Mass Index and Lumbar Bone Mineral Density for Adults

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ABSTRACT

Background: Body mass index has affect on the bone mineral density. However, a very high body mass index has been shown to be detrimental to health. But there is a gap in studies about exactly how much body mass index is most beneficial for bone mineral density. The present study aims to bridge this gap by analyzing data on body mass index saturation and its effects on lumbar bone mineral density in mid-aged adults.

Objectives: To ascertain whether there is a body mass index saturation value that existed, to maintain optimal bone mineral density and to find the association of saturation of body mass index and lumbar bone mineral density for adults.

Study design: Cross-sectional analytical study.

Place and duration of study: Medical Unit 2, Bolan Medical Complex Quetta from 1st April 2013 to 30th April 2020.

Methodology: Ninety cases were selected, comprising of 30 each of pre-menopausal women, menopausal women and men. The enrolled cases were within the age of 40-65 years. The anthropometric measurement of body mass index was performed through the digital measuring device for weight in kilograms and height in centimeters. A central DEXA scan for lumbar spine and total hip was conducted using dual energy x-ray absorptiometry. Bone mass density was measured through T scoring technique. A well-structured questionnaire was adapted for entering the demographic, clinical and body mass index and bone mineral density association.

Results: The mean age of the premenopausal women was 39.8±4.4 years, while menopausal and men enrolled had a mean age of 59.8±4.5 and 52.3±4.4 years respectively. The mean body mass index of the men and the premenopausal women was in the overweight (28.5±1.4 and 27.4±2.3) category respectively while of the menopausal women it was in the obese category with 33.1±5.1 kg/m² weight. There was significant variance in the lumbar and spine bone mineral density, premenopausal and men as highest and, menopausal as lowest. The association analysis between the body mass index and bone mineral density showed that the individuals having increased body mass index above 27 kg/m² had low T score, so that the bone mineral density was turned to a T score which showed osteoporosis in many cases, especially in menopausal group. The linear regression analysis values showed that there was a high significant association of menopausal women weight with the lumbar spine and total hip bone mineral density. The similar significance was observed in the pre-menopausal women as well as men.

Conclusion: There is a strong association between body mass index and bone mineral density of the individuals. The bone mineral density increases with the increase in body mass index, until a saturation level of 27 kg/m², beyond which the bone mineral density reduced.

Keywords: Association, Saturation, Bone mineral density, Body mass index, Lumbar bone

INTRODUCTION

The interplay between body mass index (BMI) and lumbar bone mineral density (BMD) has long intrigued researchers due to its significant implications for understanding bone health and overall physical well-being. As our population ages, the importance of elucidating the relationship between BMI and BMD becomes increasingly critical, particularly for mid-aged adults who are at a pivotal stage in maintaining bone integrity. Osteoporosis is a common degenerative disease, characterized by weakened microtexture, reduced bone mineral density and increased bone fragility. At menopause women undergo accelerated bone loss. Thereafter, men and women gradually loose bone mass. A loss of one standard deviation leads to two fold risk of spine fracture.¹ This study delves into the association of BMI saturation with lumbar BMD among mid-aged adults, a demographic often overlooked in favour of younger or older age groups, yet profoundly significant in the trajectory of bone health.²

Body mass index, a widely used index for assessing body fat based on height and weight, has been suggested to have a complex relationship with bone density. Previous research indicates that higher BMI is generally associated with increased BMD, primarily due to the mechanical loading effects of greater body mass on the skeleton. However, the saturation effect, where incremental increases in BMI yield diminishing returns in BMD,

remains less explored, especially within the context of mid-aged adults. This group, typically defined as individuals aged between 40 and 60 years, represents a crucial phase in life where both the risk of osteopenia and osteoporosis begins to escalate, necessitating a deeper understanding of the factors influencing bone density.³⁻⁵

The present study aims to bridge this gap by analyzing data on BMI saturation and its effects on lumbar BMD in mid-aged adults.⁶ The study seeks to determine whether a saturation point exists where increases in BMI no longer correlate with significant improvements in BMD, and how this relationship varies across different subpopulations within this age group. This research will provide valuable insights into how BMI impacts bone health in mid-aged adults, with implications for preventive strategies and interventions aimed at mitigating bone density loss.⁷⁻⁹

Understanding the nuances of this association is pivotal for developing targeted health recommendations and therapeutic approaches. Given the growing prevalence of obesity and its associated health complications, elucidating how BMI influences lumbar BMD could inform more effective strategies for bone health management in mid-aged adults, ultimately contributing to improved quality of life and reduced healthcare burdens associated with bone-related disorders.¹⁰

MATERIALS AND METHODS

This cross-sectional analytical study was conducted at Medical Unit 2, Bolan Medical Complex, Quetta, from 1st April 2013 to 30th

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April 2020. A total of 90 cases were selected, comprising of 30 each of pre-menopausal women, menopausal women and men. Individuals under various BMI values were enrolled in this study after they provided their consent and signed the informed written consent. A total of 90 cases were enrolled within the age of 40-65 years. The enrolled individuals were divided into three groups with each having 30 sample size. The first group was of pre-menopausal women, while second was of menopausal women and third of men. The exclusion criteria constituted of patients suffering from hyperthyroidism and diabetes. The sample size was generated using 95% CI, 80% power of test and 5% margin of error. The anthropometric measurement of BMI was performed through the digital measuring device for weight in kilograms and height in centimeters. The weight and height were measured in light clothing without shoes, kg/m². A central DEXA scan for lumbar spine and total hip was conducted using dual energy x-ray absorptiometry (DXA: STRATOS 800) technique. The DEXA scan revealed the consistency of the bone on X-ray films. The machine used was central DEXA. A Test scoring method was used for assessing the bone mineral density ≥ -1 is for healthy bone, -1 to -2.5 presented osteopenia with less severe loss of bone mineral density, whereas ≤ -2.5 meant osteoporosis. The BMI of 18.5 to 25 was taken as normal, while a BMI of 25 to 30 was considered as overweight, and above 30 was taken as obese. A BMI below 18.5 was taken as underweight. A well-structured questionnaire was adapted for entering the demographic, clinical and BMI, BMD results. The SPSS version 26.0 was applied for analyzing the results. Chi square test and linear regression analysis was used for comparison with a p value <0.001 as significant.

RESULTS

The association between BMI and BMD was observed in the study. The mean age of the premenopausal women was 39.8 ± 4.4 years, while menopausal and men enrolled in the study had a mean age of 59.8 ± 4.5 and 52.3 ± 4.4 years respectively. The mean BMI of the men and the premenopausal women was in the overweight (28.5 ± 1.4 and 27.4 ± 2.3) category, respectively, while of the menopausal women it was in the obese category with 33.1 ± 5.1 kg/m² weight. There was significant variance in the lumbar and spine BMD between premenopausal and men as highest and of menopausal women as the lowest (Table 1).

The association analysis between the BMI and BMD showed that the individuals having increased BMI upto 26 kg/m² had normal T score while as the BMI increased so that the BMD was turned to a T score which showed osteopenia followed by osteoporosis in many cases, especially in menopausal group (Fig. 1).

In context to the BMI groups the highest number of cases of obese patients was found in menopausal women, followed by men. The lowest number of normal weight women recorded was also from the menopausal group. Similarly, 60% of the menopausal women were suffering from osteoporosis risk while highest prevalence of healthy bone mass density was observed in men (53.3%), then in pre-menopausal women (46.6%). There were still cases of pre-menopause women and men who were suffering from osteopenia (Table 2).

The linear regression analysis values showed that there was a high significant association of menopausal women weight with the lumbar spine and total hip BMD. The similar significance was observed in the pre-menopausal women as well as men (Table 3).

Table 1: Association of age with body mass index and bone mineral density

Variables	Pre-Menopausal (N=30)	Menopausal (N=30)	Men (N=30)	P value
Age (years)	39.8 ± 4.4	59.8 ± 4.5	52.3 ± 4.4	<0.001
BMI (Kg/m ²)	28.5 ± 1.4	33.1 ± 5.1	27.4 ± 2.3	<0.001
Height (cm)	161.3 ± 5.4	157.4 ± 5.1	163.5 ± 12.3	<0.001
Weight (Kg)	81 ± 12.3	74 ± 5.8	73 ± 12.3	0.178
Lumbar Spine (Kg/cm ² BMD)	0.93 ± 0.22	0.86 ± 0.14	0.94 ± 0.18	0.091
Total Hip (Kg/cm ² BMD)	0.94 ± 0.23	0.87 ± 0.15	0.93 ± 0.19	0.085

Table 2: Association of body mass index categories and T score with various enrolled groups

Variables	Pre-Menopausal (N=30)	Menopausal (N=30)	Men (N=30)	P value
BMI groups				
Under weight	1 (3.3%)	-	1 (3.3%)	--
Normal	8 (26.6%)	2 (10%)	8 (26.6%)	0.322
Over weight	12 (40%)	8 (26.6%)	9 (30%)	0.453
Obese	9 (30%)	20 (66.6%)	12 (40%)	<0.001
T score				
Normal	14 (46.6%)	5 (16.6%)	16 (53.3%)	0.22
Osteopenia	11 (36.6%)	7 (23.3%)	8 (26.6%)	0.32
Osteoporosis	5 (16.6%)	18 (60%)	6 (20%)	0.002

Table 3: The Lumbar spine and total hip bone mineral density significance values in various groups

Variable	Pre-menopausal women			Menopausal			Men		
Lumbar Spine									
Weight (kg)	0.01	0.379	0.277	0.004	0.001	0.231	0.03	0.052	0.100
BMI (kg/m ²)	0.001	0.512	0.269	0.101	0.181	0.04	0.013	0.045	0.122
Total Hip									
Weight (kg)	0.001	0.312	0.005	0.002	0.001	0.372	0.005	0.041	0.087
BMI (kg/m ²)	0.002	0.412	0.019	0.01	0.001	0.371	0.018	0.027	0.112

DISCUSSION

The relationship between age and bone mineral density (BMD) has been well-documented, with numerous studies highlighting an inverse correlation. As individuals advance in age, particularly between 40 and 65 years, BMD typically declines due to a combination of factors including reduced bone formation, increased bone resorption and hormonal changes.¹¹ Jansen et al¹² consistently presented through their research that this age-related decline in BMD accelerates with time, contributing to an elevated risk of osteopenia and osteoporosis. Palermo et al⁹ stated that the age-related decline is particularly pronounced in mid-aged adults, a group that faces increasing challenges in maintaining bone health as they transition through this critical life stage. The gradual

Fig. 1: Association of body mass index with bone mineral density

loss of bone density in this demographic underscore the need for targeted preventive measures and early intervention strategies to manage bone health effectively.¹³⁻¹⁵

Conversely, the relationship between BMD and body mass index (BMI) reveals a positive correlation. Rinonapoli et al¹⁶ have demonstrated that as BMI increases, BMD also tends to rise, especially in mid-aged adults. This association is attributed to the mechanical loading effect of increased body mass, which stimulates bone formation and can lead to higher BMD. Moreover, the study's findings suggest that in mid-aged adults, obesity is associated with greater BMD, likely due to the additional mechanical stress imposed on the skeletal system.¹⁷⁻¹⁹

It has been that although, body mass index positively affected bone mineral density, however an excessively high BMI was detrimental to health, especially for the elderly. The saturation value association between BMI and BMD for people over 50 years old and keeping the BMI in slightly overweight value (around 26 kg/m²) might reduce other adverse effects while obtaining optimal BMD.¹⁰ Another study showed that maintaining BMI at a moderate level (around 24.3 kg/m²) would result in an optimal balance between BMI and BMD in adults over 50 years old.¹⁴

However, it is crucial to recognize that while increased BMI might correlate with higher BMD. This does not necessarily translate to overall bone health or reduced fracture risk, as other factors such as fat distribution and quality of bone play significant roles. Thus, while BMI can be a useful indicator of bone density, its implications for bone health should be considered alongside other health metrics and individual risk factors.^{18,19} These findings highlight the complexity of the relationship between BMI and BMD in mid-aged adults and underscore the need for a nuanced approach to bone health assessment and management in this age group.²⁰

CONCLUSION

In persons over age of 40 years, our research found a positive relationship between obesity and BMD, and a saturation value between BMI and BMD was found. By maintaining BMI at a moderate level (around 27 kg/m²) an optimal balance between BMI and BMD in adults over 40 years may be achieved. Thus there is a strong association between BMI and BMD as well as Age of the individuals. The BMD increases with the increase in BMI while the BMD decreases with the increase in age.

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