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Evaluation The Relation Between Body Mass Index And Bone Mineral Density Measure By DEXA

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Abstract
Background: *Using dual-energy X-ray absorptiometry, Body mass index and Bone mineral density have been determined. The assessment of bone mineral density was conducted utilizing dual-energy X-ray absorptiometry analysis of the pelvis and lumbar spine. While it is acknowledged that osteoporosis can impact bone mineral density in relationship with body mass index, the particulars of this relationship currently remain uncertain.*
Objective: *The main objectives of the current study are to evaluate the relationship between different categories of BMI and BMD in the lumbar spine and pelvis. And which one of the BMI categories is more effective on the BMD of the lumbar spine and pelvis?*
Method: *Tow hundred and fifty individuals participated (100 control and 115 patients) in this study. Patients who presented with bone discomfort consisted of 55 males and 65 females. In addition, 90 apparently healthy volunteers, consisting of 45 males and 55 females, were studied and considered to constitute the control group. Dual-energy X-ray absorptiometry was utilized to determine the bone mineral density of every participant for all body parts. For all participants were measured height and weight to determine body mass index.*
Results: *Results: Statistically significant disparities in bone mineral density were observed among the underweight, normal weight, and overweight for all participants (healthy and patient). Also, there was a statistically significant difference in BMD between the pelvis and lumbar vertebrae for both sexes.*
Conclusions: *Our findings demonstrate that females possess a lower bone mineral density compared to males. Overweight BMI is more effective on BMD of the lumbar vertebra and pelvis bones. The pelvis is more influenced by BMI than the lumbar vertebrae*
Keywords: Bone mineral density, Dual-Energy X-Ray Absorptiometry scan, Bone Mineral Density, Osteoporosis, Body Mass Index

INTRODUCTION

Accurate results are essential in medical examinations, necessitating the precise recording of patient information. The patient's age and sex can be directly determined; however, accurate measurement of height and weight is essential. Body mass index (BMI) is essential in radiological diagnosis. The patient's weight significantly influences mineral absorption in the body; therefore, BMI has an effect on assessing bone mineral density (BMD) for osteoporosis evaluation, which is measured by Dual-Energy X-ray Absorptiometry (DEXA) [1].
The most effective method of assessing bone quality in clinical management is to determine bone mineral density (BMD). Furthermore, when it exceeds or falls below the normal range, it is indicative of bone health issues [2]. For instance, an elevated risk of fracture is associated with alterations in bone mineral density (BMD) in bony skeleton of the human body. Bone mineral density scanning is an enhanced version of the X-ray technique that can enhance directional accuracy and spatial resolution. Dual-energy X-ray absorptiometry (DEXA) allows for rapid and minimal radiation exposure due to its rapid processing time. This renders the technique more advantageous than those that were previously implemented [3].
To conduct the BMD examination, the attenuation characteristics of different materials within the body are assessed about photon energy. Numerous potential sites exist for testing; however, the lumbar spine, hip, and femur are the most frequently selected options. They generally perform a comprehensive scan of

the whole body [4]. The primary advantage of the assessment is that it provides a precise BMD value (g/cm^2), facilitating direct comparisons with prior scans to enhance understanding of a patient's health history in relation to their age and gender [5]. A DEXA scan may assess various body regions and differentiate between fat and lean mass by utilizing the distinct attenuation characteristics of tissues. This facilitates the assessment of bone health status [6].

In 1994, the World Health Organization (WHO) established the appropriate threshold values for the diagnosis of osteopenia and osteoporosis using DEXA scans. The DEXA scan subsequently became the most effective method of examination in the field of bone densitometry, as these thresholds are considered the gold standard for the clinical diagnosis of bone health condition. Based on the T-score, the WHO reported that bone mineral density is normal when it is between -1 till -1.0, osteopenia when it is between -1.0 till -2.5, osteoporosis when it is below 2.5 and severe osteoporosis when it is well below -2.5 and there are fragility fractures [7, 8].

The body mass index (BMI) of an individual is determined by their weight and height. The Body Mass Index (BMI) is the ratio of body mass (kg) to the square of body height (m^2), given in kg/m^2 [9,10]. The primary classifications for adult are underweight when BMI (< 18.5 kg/m^2), normal weight (18.5 kg/m^2 to 24.9 kg/m^2), overweight (25 kg/m^2 to 29.9 kg/m^2), and obese (30 kg/m^2 or above) [11].

Some studies have suggested that early postmenopausal women with low BMI (less than 24.4 kg/m2) lose more bone than those with higher BMI (greater than 27.7 kg/m2) [12]. An additional investigation discovered a correlation between osteoporosis, thinness, and an elevated risk of fracture [13]. The importance of exercise in relation to bone mineral density (BMD) is emphasized in a multitude of studies conducted by a variety of authors. One of these authors was proposing that the BMD is optimized by exercise at a younger age [14]. The development of osteoporosis is influenced by a variety of factors, such as a family history of osteoporosis and fractures, diabetes, a disturbance in lipid profile, cardiovascular disease, and nutrition [15]. Low weight might be associated with osteoporosis among the anthropometric variables. A low BMI is a valuable indicator for the referral of women under the age of 60 for BMD measurements [16].

The current study aims to evaluate the relationship between different categories of BMI and BMD in the lumbar spine and pelvis. And which one of the BMI categories is more effective on the BMD of the lumbar spine and pelvis?

METHOD

The Rheumatology Outpatient Clinic at Al-Yarmouk Teaching Hospital in Baghdad hosted our study from July to November 2024. The main objective was to investigate the impact of body mass index (BMI) on bone mineral density (BMD). A DEXA scan of the participants' spines and pelvises was used to measure their bone mineral density (BMD). Both healthy (with out osteoprosis and patients underwent this procedure. As a control group, 100 apparently healthy individuals were randomly selected, while 115 patients with bone discomfort attended the rheumatology clinic for the study. The study's participants ranged in age from 20 to 45 years, with body weights ranging from 31 to 92 kg and body height was from 158 to188 cm. Table 1 divides these participants into categories based on complaints of intellectual disability or otherwise. Table 2 further classifies each participant based on their sexes.

Table 1: Distribution of study participants

Total no of participants	Control (Healthy subjects)	Patients (suffer from bone pain)
215	100	115

Table 2: Sexes distribution of participant

	Total Number	Female	Male
Control group	100	55	45
Patients (suffer from with bone pain)	115	60	55

All the samples (215 individuals) participated in the survey, which inquired about the following questions: smoking status (e.g., duration of electronic or cigarette use), blood pressure, iron deficiency, diabetes, and work routine or stress. The study's exclusion criteria encompassed patients with cancer, specifically those undergoing radiotherapy or chemotherapy, as well as individuals who smoke. Participants were required to respond to a set of inquiries, which included a diabetes and iron examination for the patient group (where the diabetes and iron concentrations in the blood of all samples were determined in the biochemical analysis laboratories within the same hospital) and a DEXA instrument measurement of bone mineral density for the lumbar spine and pelvis.

Measurements: The DEXA device was utilised to assess the bone mineral density of the lumbar spine and pelvis in all groups in both control and patient groups of the males and females.

Statistical analysis:

Statistical analyses were conducted utilising version 22 of the Statistical Package for the Social Sciences (SPSS for Windows, IBM Inc.). The differences were between control (normal: no osteoporosis) and (osteoporosis by any disease) for different of BMI.

RESULTS

For the participants' demographic attributes, the mean ± SEM age was 39.45 ± 2.5 cm for males and 40.25 ± 2.65 cm for females the mean ± SEM height was 172.55 ± 2.65 cm for males and 165.75 ± 1.65 cm for females, and the mean ± SEM weight was 78.85 ± 6.75 kg for males and 82.55 ± 5.25 kg for females. The BMI of the participants was calculated depending on equation 1; therefore, the BMI is divided into three categories, as elucidated in table 3.

Table 3: Body Mass Index (BMI) for all participants in the study

Groups	Mean ± SEM	
	BMI kg/m^2 (Male)	BMI kg/m^2 (Female)
Low weight	16.17 ± 0.85	17.22 ± 1.2
Normal weight	23.43 ± 1.72	22.55 ± 1.55
Overweight	26.97 ± 1.55	28.35 ± 1.6

Relationship between BMD and BMI of the pelvis for both sexes

Table (4) demonstrates that there are no significant differences in the mean values of BMD of the healthy pelvis in the normal weight case when compared with the mean values of BMD of the underweight and overweight for the female, which also applies in the case of the males. As well as when applies in the patient cases.

Table 4: Bone mineral density of the pelvis (healthy and patient) of females and males participated in current study

	Underweight	Normal weight	Overweight
Male (Pelvis healthy)	0.965	0.995	0.927
Male (Pelvis Patient)	0.642	0.675	0.595
Female (Pelvis healthy)	0.955	0.975	0.932
Female (Pelvis Patient)	0.625	0.635	0.56

Table (4) shows that there is a reduction in the mean values of BMD in the patient pelvis in the males of all groups (underweight, normal weight and overweight) when compared with the BMD of the same groups of the healthy males, which also applies in the case of the females. The mean BMD values of the underweight, normal weight, and overweight male patients were 33%, 32%, and 36% lower than the mean BMD values of the healthy male patients. Similarly, the mean BMD of the pelvis values of the underweight, normal weight, and overweight patient females showed a reduction of 34%, 35%, and 40%, respectively, compared to the mean BMD values of the healthy females. There were highly significant differences (P < 0.001) in the mean BMD values between the underweight, normal weight, and overweight males who were healthy and males who were patients. Also, highly significant differences (P < 0.001) were reported in the mean BMD values between the underweight, normal weight, and overweight of the healthy females in comparison with the patient females, (Figure 1).

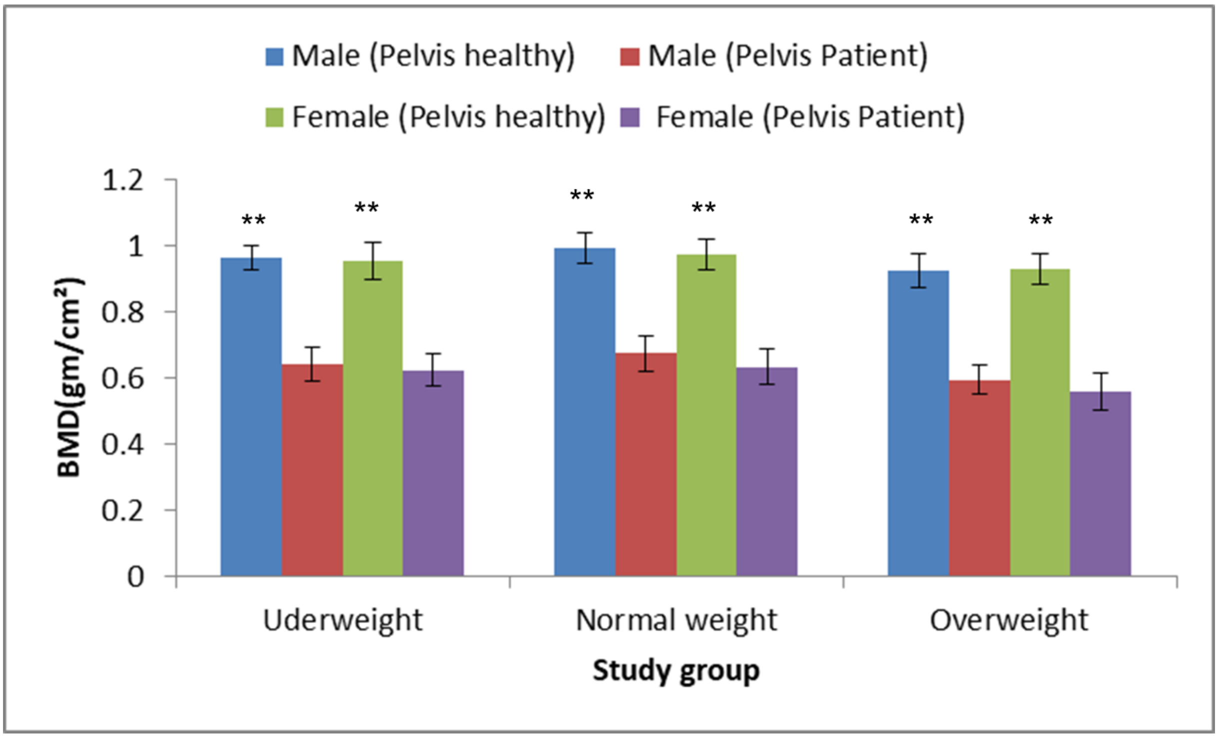

Figure 1: Comparison of the mean values of BMD of the pelvis (healthy and patient) and BMI between females and males participated in current study. **significant differences compared to the healthy subjects (p<0.001).

Relationship between BMD and BMI of the lumbar spine for both sexes

Table 5: Bone mineral density of the lumbar spine (healthy and patient) of females and males participated in current study

	Underweight	Normal weight	Overweight
Male (Lumbar spine healthy)	0.993	0.995	0.955
Male (Lumbar spine Patient)	0.692	0.675	0.615
Female (Lumbar spine healthy)	1.04	0.989	0.94
Female (Lumbar spine Patient)	0.682	0.645	0.565

Table (5) shows that there is a reduction in the mean values of BMD in the healthy lumbar spine in the males of all groups (underweight, normal weight and overweight) when compared with the BMD of the same groups of the patient males, which also applies in the case of the females. The mean BMD values of the underweight, normal weight, and overweight male patients were 30%, 32%, and 36% lower than the mean BMD values of the healthy male patients. Similarly, the mean BMD values of the underweight, normal weight, and overweight patient females showed a reduction of 34%, 35%, and 40%, respectively, compared to the mean values of the healthy females. There were highly significant differences (P < 0.001) in the mean BMD values between the underweight, normal weight, and overweight healthy males and patient males. Also, highly significant differences (P < 0.001) were reported in the mean BMD values between the underweight, normal weight, and overweight of the healthy females in comparison with the patient females, (Figure 2).

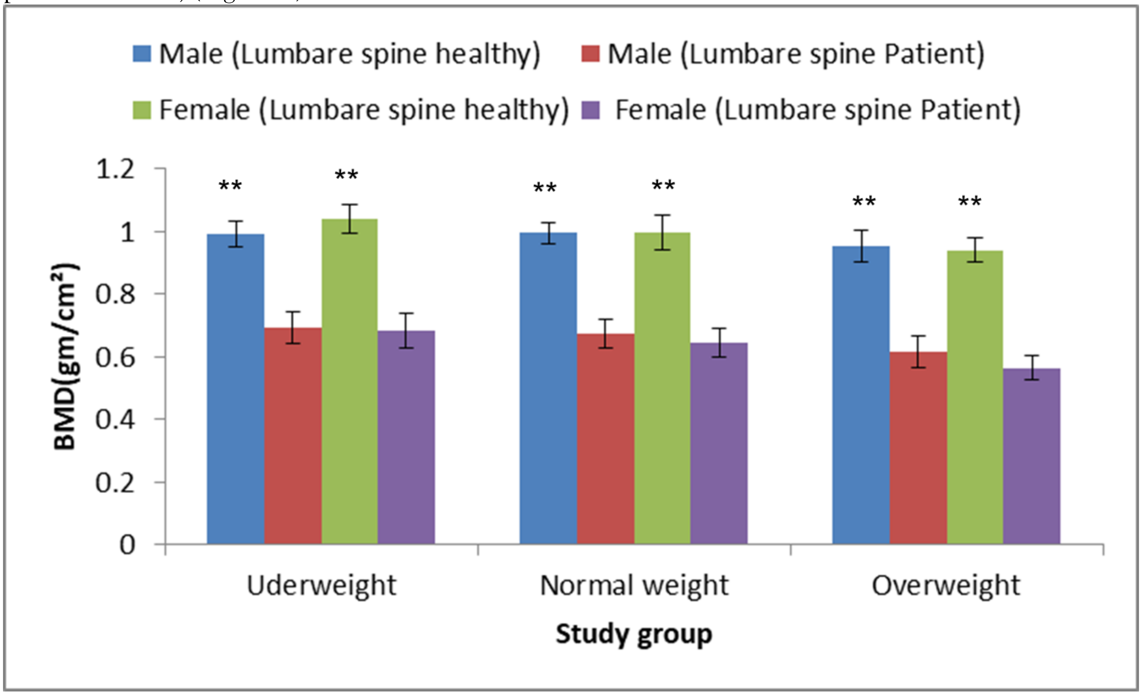

Figure 2: Comparison of the mean values of BMD of the lumbar spine (healthy and patient) and BMI between females and males participated in current study. **significant differences compared to the healthy subjects ($p<0.001$).

DISCUSSION

All participants in this study had been taken from people who visited the rheumatology outpatient clinic complaining of body pain or joint pain; a good percentage of them had diagnoses of muscle spasm, or stress of joint ligaments, and not osteoporosis.

Generally, body mineral density of the lumbar vertebra, hip bone, and head of the femur is usually used to be representation to the BMD of the body of any subject. Both T-score and Z-score consider the value (+1 to -1) normal mineral density, (-1 to -2.5) osteopenia, and less than -2.5 represents osteoporosis [17].

The body weight and height are not references involved in the calculation of T-score and z-score equations (i.e., not considered in the calculation of BMD). The researchers of this study focused on the T-score and Z-score values (by BMD) vs. body mass index values of people who needed to be examined using a Dexa scan. Body mass index (BMI) is revealed by using the body weight to height square ratio (body weight/height^2), i.e., the researcher put in this consideration the weight and the height of the patients to compare the T-score and Z-score values with under BMI, normal BMI, and overweight (high BMI) [18]. This means that the researchers try to avoid using the weight alone since this gives false results. For this reason, to provide an accurate result, the researchers used BMI.

The study's results showed that people with a normal BMI usually had good body mineral density. On the other hand, people who were underweight had a significant drop in BMD, which was shown by low T-score and Z-score. This could be explained by the fact that underweight patients (low BMI) usually had health problems, which led to a reduction in body weight and inverse body height (this could be due to malnutrition, lifestyle, or some hidden disease, mainly endocrine diseases) [19].Regarding overweight patients (i.e., those with high BMI), the results elicited a highly significant reduction in the body mineral index (appeared as a low T-score and Z-score below -2.5). This reduction in BMD of overweight (high BMI) could be attributed to the overweightness of their body, which led to an decrease in BMD on their vertebral column, specifically the lumbar vertebra, then the pelvis, and then the femora [20] Additionally, overweight patients have low mobility because of their overweight and changes in this lifestyle. Besides, being overweight could be due to a hidden abnormality in their endocrine system or bad habits in their food intake [21].

Our results showed that females had lower BMD than males. Females' lifestyle, mobility, and type of work, as well as hormones and pregnancy, could potentially contribute to this result.
One of the intriguing results that were illustrated from this study is that the pelvis mineral index is more accurate than the lumbar vertebral bone index. Up to our knowledge, no research highlights this point. The cause behind this finding could be explained as follows:
The burden of body weight, besides hard work and height, usually pressed mainly on lumbar vertebrae, then the pelvis, and finally the femor. The vertebral column, pelvis, and femor are considered the axial bony skeletons of the body. The movement of thoracic vertebrae is negligible because of their attachment to ribs and the sternum [22].
The lumbar vertebra has the ability to move besides the presence of intervertebral discs, which act as shock absorbers. The pelvis loses this character. It is formed of the sacrum (which is fused five sacral vertebrae), which is articulated with bilateral hip bones, which presents as a single bone. The sacrum articulates strongly with both hip bones, functioning as a single bone. This lets the movement of the pelvis bone be considered as if it was one bone without movement [23, 24].
Once the axial bony part of the bony system was described, it became clear that the pelvis bone will be most affected by body weight, hard work, and lifting heavy weight [25]. Therefore, the body mineral indexes of the pelvis give an accurate indication of the generalized body mineral density of the whole body.

CONCLUSION

Our findings demonstrate that females possess a lower bone mineral density compared to males. Overweight BMI is more effective on BMD of the lumbar vertebra and pelvis bones. The pelvis is more influenced by BMI than the lumbar vertebrae. Consequently, body mass, hard work, and the lifting of substantial weights will predominantly influence the pelvic bone. Consequently, the pelvic mineral density indices provide a precise index of the whole body mineral density level.

Study limitations

Our study has many limitations, including a small sample size for both the patients and healthy subjects (controls). In addition, the study did not take into account the association of BMI with specific diseases that have a direct or indirect effect on bone mineral density.

Recommendation

We are recommended that the inclusion of BMI in the assessment of the risk of pelvis and lumbar vertebrae osteoporosis and osteoporotic fractures.

Conflict of interests

No conflict of interests was declared by the authors.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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