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ABSTRACT

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INSIGHTS INTO THE RELATIONSHIP BETWEEN BONE MINERAL DENSITY AND TRABECULAR BONE SCORE AND THEIR PHYSIOLOGICAL CORRELATION WITH BODY MASS INDEX IN POSTMENOPAUSAL WOMEN WITH OSTEOPOROSIS

Background: People with a high body mass index (BMI), are somewhat protected against osteoporosis. Osteoporosis is a complex condition that primarily affects postmenopausal women and causes substantial morbidities and fatalities. Bone mineral density (BMD) evaluates just one of the many factors that affect bone. (TBS) is the trabecular bone score derives from DEXA scan images. It has been noted that there is a positive connection between BMD and a high body mass index (BMI).

Objective: This study aims to clarify for present any link between T-score, TBS, BMD, and BMI in postmenopausal women who had suffers from osteoporosis.

Methods: 566 postmenopausal women were chosen from the Alzahraa center of the Ibn-Albitar Private Hospital in Basrah, Iraq, for this study. Dual X-ray absorptiometry (DEXA) was used to measure the BMD of the L1–L4 vertebrae, and the TBS iNsight program was used to calculate the trabecular bone score from the same area of the participants' spine.

Results: In patients with osteoporosis and low bone density, there was a statistically significant negative connection between TBS and BMI. BMI and TBS did not substantially correlate in patients with normal T-scores ($P > 0.01$). Additionally, among participating individuals with osteoporosis, there was a noteworthy positive correlation between high BMI and TBS-T-score.

Conclusions: Higher BMI was linked to a lower TBS in patients with an aberrant T-score, despite the fact that it had a preventive effect against osteoporosis. However, among patients with normal T-scores, BMI had no discernible impact on TBS.

Keywords: Body mass index, Trabecular bone score, Bone mineral density, Osteoporosis, Postmenopausal women.

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INTRODUCTION

In postmenopausal women, osteoporosis is a common bone disease that is defined by microarchitecture changes in bone tissue and a decrease in bone mass relative to normal levels [1]. Indeed, bone fractures are the most frequent consequence of osteoporosis, and an estimated a millions occurrences of osteoporosis related fractures are recorded annually worldwide, although fractures can happen anywhere in the skeletal system, they most frequently happen in the vertebrae, proximal femur, and distal forearm, however, a study conducted on the Swedish population found that BMD alone is not a highly reliable indication of fracture risk. [2]. The most plausible reason for this is that fracture risk is impacted by both the 3-dimensional (3D) microarchitecture of the bone tissue and the quantity of bone mineral as determined by BMD [3]. The trabecular bone score (TBS) was created to identify the microarchitecture of the bone in order to get beyond the drawbacks of BMD. A texture property called TBS measures variations in the gray-level of pixels in DEXA images [4]. According to a number of researches, TBS can provide information regarding the structural state of bone microarchitecture. A compact, robust, and fracture-resistant microarchitecture with small gaps between spans is reflected in higher TBS values [5]. Numerous retrospective cross-sectional studies have shown that TBS is equally useful as BMD for identifying fractures in patients, and some have even found that using TBS and BMD together produced better results [6, 7]. Furthermore, it was established that TBS was just as good as areal BMD at predicting lumbar spine (LS) fractures. Prior research has demonstrated significant connections between body mass index (BMI) and bone mineral density (BMD), additionally, it has been noted that the accumulation of abdominal weight has a direct impact on TBS [8]. According to a number of researches, TBS can provide information regarding the structural state of bone microarchitecture. A micro-architecture with small gaps between spans that is dense, robust, and fracture-resistant is reflected in higher TBS values [9]. Conversely, a low TBS value indicates a microarchitecture that is weak and prone to fracture, with wide gaps between spans. As a trabecular pattern index of the measured bone, TBS may be associated with bone strength [10]. BMI and TBS have been found to be negatively correlated in certain human studies, while BMI and LS-BMD have been found to be positively correlated [11]. Consequently, it is yet unknown how TBS, LS-BMD, and BMI are complexly related, furthermore, the group of the researcher's in Turkey only focuses in search on age and fracture [12]. Currently they did not find such studies that emphasize the connection between TBS/BMD and height, weight, and BMI, although TBS and BMD have different units, they can be reliably compared because they are translated into T scores. The current study sought to ascertain whether there is a relationship between LS-BMD and TBS that varies with BMI in postmenopausal women.

MATERIALS AND METHODS

Study design and setting

From January 2024 to January 2025, this study was conducted on 566 postmenopausal women who were sent to the Alzahraa Center Department at Ibn Albitar private Hospital in Basrah, Iraq. Three age-based patient groups (50–59), (60–69), and over 70 were established, the body weight between (50-85 kg and average length 145-165 cm).

Patient selection

Eligible patients had interpretable DEXA scans and were at least 50 years old. Age, height, weight, BMI, menopausal status, physical activity, and smoking were among the demographic information. It should be noted that the permanent cessation of monthly bleeding for a minimum of one year was the definition of menopause. Hormonal disorders, orthopedic conditions, malignancies, secondary causes of osteoporosis including hyperparathyroidism, vitamin D intake, and other drugs or substances that could alter bone metabolisms, like steroid abuse, were among the exclusion criteria. A wall-mounted stadiometer and an electronic scale were used to measure the patients' height (in meters) and weight (in kilograms) to determine the BMI, it is calculated by using an equation in which the body weight is divided by the square of the height according to the following:

BMI= Weight (kg) / Height (m^2)

Body mass index is a measurement of body fat which classified as underweight (<20), normal (20–25), overweight (25–30), and obese (> 30) [13].

Operational definition

The following categories were used by the World Health Organization and the United States National Osteoporosis Foundation to classify BMD:

- A BMD score that is less than one standard deviation below the peak bone mass of healthy adults is considered normal.

- Osteopenia: A BMD value that is 1.0 (SD) to 2.5 (SD) below the typical peak bone mass of healthy persons.

- A bone mass index (BMD) greater than 2.5 (SD) below the mean of healthy persons' peak bone mass is considered osteoporosis [14].

Evaluation of bone density and assessment of the trabecular bone score

The bone mineral densities (BMD, g/cm2) of the lumbar spine were determined for each woman by using a single DEXA scan (GE Lunar Prodigy, USA, software version 16). Also, utilize the TBS iNsight software version 16 (USA), the DEXA lumbar spine (L1-L4) images as in (Figure 1) were reanalyzed in order to calculate TBS, a DEXA-derived parameter based on the gray-level analysis of DEXA pictures. The data obtained from DEXA pictures was used to compute lumbar spine TBS T-scores. The regions used for the BMD analysis and the trabecular bone score estimation are comparable. Three groups includes: the normal microarchitecture (NM) group, the partially deteriorated microarchitecture (PDM) group, and the degraded microarchitecture (DM) group were created from the patients' TBS scores [15].

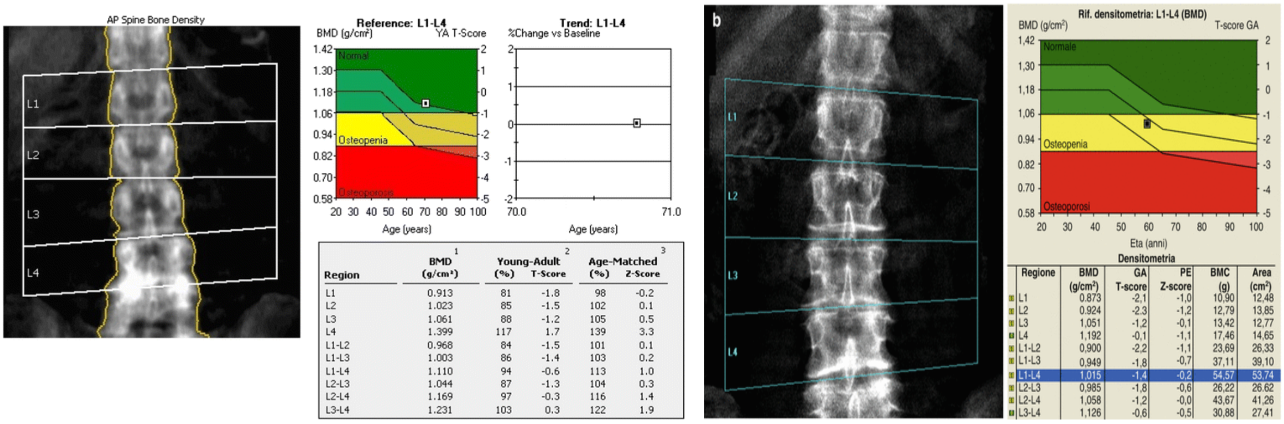

Figure 1 – Examples of DEXA scans of the lumbar spine of women, and graphs from the digital indicators

Statistical Analysis

Clinical characteristics, TBS, and BMD data were compared between the three groups using the one-way analysis of variance (ANOVA). SPSS (version 24.0), a statistical program, is used to analyze every variable. Means ± SD ($P \leq 0.05$) were used to express descriptive statistics.

RESULTS

The demographic and clinical characteristics of the study participants' groups are displayed in the Table 1, where we can observe the distribution of ages, heights, and weights for the groups involved, the correlation between BMI and study categories includes the mean average of normal, underweight, over weight and obese.

The BMD T-score, TBS T-score, and osteoporosis mean of the female research participants throughout the various age groups can be seen in Table 2, along with their relationship to the TBS split in the tables by degraded, partially degraded and normal.

The Table 3 explains the statistical significance decrease between the groups that participated based on the ages division and the association of patients with BMD T- score, BMI and TBS values. They show differences for the age groups with normal, low bone mass and osteoporosis in different categories.

Table 1 – Anthropometric traits and BMI categories of the ladies under investigation (Sample size 566)

Variables	Mean ±SD
Age (yrs.)	62.3± 1.06
Height (cm)	158.2± 2.11
Weight (kg)	78.5± 1.41
BMI (kg/m^2)	29.3± 0.39
Normal	21.96± 1.09
Under weight	17.72± 1.12
Over weight	28.91± 1.33
Obese	34.58± 2.17

Abbrs: Body mass index (BMI)

Table 2 – The trabecular bone score and bone mineral density of the women under examination (Sample size 566)

Variables	Mean ± SD
BMD T-score	- 0.27 ± 1.4
Osteoporosis	- 3.4 ± 1.22
Low bone mass	- 1.69 ± 1.63
Normal	0.6 ± 1.03
T- score LS	-2.8± 1.29
TBS T- score	0.23 ± 1.16
TBS Degraded	1.17± 2.01
TBS Partially degraded	1.33± 2.11
Normal TBS	1.49± 2.24

Abbrs: Bone mineral density (BMD); trabecular bone score (TBS); and standard deviation (SD)

While Table 4 shows the distribution of BMI according to the number of women participating in the study and its relationship with the statistical average and the degrees of T-score values in the spine and TBS, as well as the values related to them within the target group.

DISCUSSION

TBS is a bone texture metric that was mostly used to study for women whose suffers from low bone density, in this study; we examined TBS in individuals who were classified according to BMD into three groups: normal, osteoporosis, and osteopenia. We also assessed the associations between TBS and clinical factors (weight, height, and BMI) in each group. According to earlier research, there is considerable debate regarding the relationship between TBS and BMI. There was no association between TBS and BMI in a study including 250 Italian men and women [16]. In contrast, another study found that among 1,474 postmenopausal Korean women, TBS and BMI were positively correlated [17].

Table 3 – Patients with osteoporosis and low bone mass in various age groups were measured for BMI and TBS

BMD T- score	BMI*	TBS*	P value
50-59 years (n=202)			
Normal (n=64)	31.2± 2.29*	1.38± 1.14	≤ 0.05
Low bone mass (n=81)	30.06± 2.39	1.35± 1.11*	≤ 0.05
Osteoporosis (n=57)	28.58± 2.36*	1.28± 1.3*	≤ 0.05
60-69 years (n=248)			
Normal (n=53)	30.46± 2.06	1.36± 1.09	≤ 0.05
Low bone mass (n=110)	29.28± 2.19	1.30± 1.05*	≤ 0.05
Osteoporosis (n=85)	28.19± 2.33	1.26± 1.16	≤ 0.05
≥70 years (n=116)			
Normal (n=20)	27.81± 2.38*	1.34± 1.01	≤ 0.05
Low bone mass (n=49)	30.72± 2.44	1.25± 1.22*	≤ 0.05
Osteoporosis (n=47)	24.29± 2.02*	1.22± 1.14*	≤ 0.05

*Note: *Mean ± SD significant decrease between categories*

Table 4 – Correlation and descriptive data between TBS and LS-BMD in various BMI groups

BMI	Numbers	TBS- Scores**	LS- T- score*	TBS vs. LS- T-score*	P value
<17.7	14	1.09± 0.16	-2.7± 1.2	-1.321	≤ 0.05
17.7-21.9	158	1.19± 0.11	-2.4± 1.21	-1.153	≤ 0.05
22-28.9	233	1.29± 1.13	-1.7± 1.17	-0.226	≤ 0.05
29-34.5	161	1.21± 1.19	-1.2± 1.16	0.043	≤ 0.05
Total	566	1.22± 1.01	-2.2± 1.1	-1.074	≤ 0.05

*Note:*Mean ± SD significant decrease;*
***Mean ± SD significant increase*

Other researchers, however, found a weak negative association; therefore, additional research is needed to remove the current uncertainty. The connection between body fat and BMI, indicate that those with high BMI also tend to have high body fat percentages [18]. In line with the findings of previous research, we showed a favorable association between BMI and BMD in this study, different mechanisms of BMI's impacts on the microarchitecture of trabecular bone and BMD may help to explain the varied relationships between TBS, T-scores, and BMI [19]. Furthermore, there aren't many studies looking into these correlations at the same time, even if there have been several on the relationship between BMI and T-scores or between BMI and TBS individually [20]. In a related study, the individuals with osteoporosis and poor bone mass, TBS and BMI significantly correlated negatively. Additionally, they discovered a negative relationship between TBS and weight, which contradicts our results [21]. In another study the revealed that TBS and BMI had a strong negative association while BMD and BMI had a substantial positive correlation, while low bone density is associated with low BMI, high bone density is associated with high BMI that given the strong correlation between BMI and fat mass, it follows that fat mass and BMD are favorably connected in both males and females, the positive relationship between high BMI and BMD suggests that when fat builds up, bone density rises [22, 23]. Insulin resistance associated with bone strength increase with body weight; also it has a negative correlation with bone strength (compression, bending, and impact strength) but no significant correlation with bone mineral density (BMD) [24, 25]. Consequently, this correlation may help to explain why TBS, which seems to provide a more comprehensive view of bone strength, declines as BMI, rises. Prior research also demonstrated a negative relationship between TBS and BMI, which is consistent with our findings [26]. The discrepancies in the appearance of the results and the significant differences between the values of the T-score and the TBS indicate a relationship with the increase in body mass known as BMI for most of the women participating in the study, while the appearance of a decrease in the TBS and the absence of a difference in the BMD values gives a clear explanation that the increase in the BMI leads to stimulating the concentration of calcium in the vertebrae, which leads to the appearance of normal values in the BMD compared to low values for the TBS [27, 28]. The internal fine structures of the bones begin to lose the reinforcements that document the internal cohesion of these structures, which in the future leads to the emergence of osteoporosis, giving negative results regarding the BMD values that are in line with the TBS values in the future if the appropriate treatment and precautions are taken to prevent the development of the disease and its entry into the dangerous stage, causing future fractures that prevent rapid healing and lead to death in relation to the elderly in individuals within the community [29, 30].

CONCLUSIONS

In general, a noteworthy positive connection between T-scores and BMI was discovered. In addition, a noteworthy inverse relationship between BMI and TBS was found in postmenopausal women with poor bone mass and osteoporosis. This shows that in these females groups, a higher BMI is linked to a lower TBS but has preventive benefits against osteoporosis. More extensive population-based research is necessary to give more compelling evidence on the precise relationships between TBS, T-score, and body size factors in postmenopausal women.

Study limitations

This study only measured osteoporosis in postmenopausal women in the Basrah Governorate, concentrating on a single diagnostic facility. We might not be able to extrapolate these findings to all Iraqis due to the disparities in their surroundings, traditions, and way of life. Consequently, in-depth study is required to incorporate other categories across more expansive regions of Iraq.

AUTHOR CONTRIBUTIONS

All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

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CONFLICT OF INTEREST

There were no potential conflicts of interest pertaining to this article.

ETHICAL CONSIDERATIONS

The study was authorized by the Ethics and Professional Conduct Committee of the College of Medicine, Basrah University, and permission was granted by the Presidency of Basrah University, Iraq (030405-006-2024).

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