Al-Rafidain J Med Sci. 2024;6(2):111-115.
DOI: https://doi.org/10.54133/ajms.v6i2.800

AJMS

Online ISSN (2789-3219)

Research Article

The Relationship between Anemia and Bone Mineral Density Measured by Dual X-Ray Absorptiometry

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Received: 5 April 2024; Revised: 16 May 2024; Accepted: 20 May 2024

Abstract

Background: The bone mineral density of the lumbar vertebra has been assessed according to the results of the Dual-Energy X-Ray Absorptiometry (DEXA). Although anemia is known to affect bone mineral density, at the present time, it is not clear which vertebra is more affected by this disease. ***Objective***: To evaluate the effects of anemia on the bone mineral density of the lumbar vertebra in comparison with a normal subject and determine which part of the lumbar vertebra is more affected by anemia. ***Methods***: All 205 participants in this study complained of bone pain (90 males and 105 females). 95 patients, including both sexes, suffered from anemia. Additionally, the study included 110 seemingly healthy volunteers as the control group. All participants were studied regarding their bone mineral density for lumbar vertebrae using dual-energy x-ray absorptiometry. ***Results***: The DEXA outcomes revealed highly statistically significant differences between the control and patients of each lumbar vertebra in the same sex. In addition, there were significant differences in bone mineral density among the lumbar vertebrae of the same sex. ***Conclusions***: Our findings suggest that examining the bone mineral density of the lumbar vertebrae is a more effective and appropriate method for studying the bone mineral density (BMD) of the bony skeleton in any subject, with L1 and L4 vertebrae being more susceptible to osteoporosis than other vertebrae.

Keywords: Anemia, DEXA, Osteoporosis, Lumbar vertebrae.

العلاقة بين فقر الدم وكثافة المعادن في العظام التي تقاس بواسطة قياس امتصاص الأشعة السينية المزدوجة

الخلاصة

الخلفية: تم تقييم كثافة المعادن في العظام في الفقرات القطنية وفقا لنتائج قياس امتصاص الأشعة السينية ثنائي الطاقة (DEXA). على الرغم من أنه من المعروف أن فقر الدم يؤثر على كثافة المعادن في العظام، إلا أنه في الوقت الحالي ليس من الواضح أي فقرة أكثر تأثرا بهذا المرض. **الهدف**: تقييم آثار فقر الدم على كثافة المعادن في العظام في الفقرات القطنية بالمقارنة مع الحالة الطبيعية وتحديد أي جزء من الفقرات القطنية يتأثر أكثر بفقر الدم. **الطريقة**: اشتكى جميع المشاركين البالغ عددهم 205 في هذه الدراسة من آلام العظام (90 من الذكور و 105 من الإناث). 95 مريضا، بما في ذلك كلا الجنسين، يعانون من فقر الدم. بالإضافة إلى ذلك، شملت الدراسة 110 متطوعين يتمتعون بصحة جيدة كمجموعة ضابطة. تمت دراسة جميع المشاركين فيما يتعلق بكثافة المعادن في عظامهم للفقرات القطنية باستخدام قياس امتصاص الأشعة السينية ثنائي الطاقة. **النتائج**: كشفت نتائج DEXA عن اختلافات ذات دلالة إحصائية عالية بين المجموعة الضابطة والمرضى في كل فقرة قطنية في نفس الجنس. بالإضافة إلى ذلك، كانت هناك اختلافات كبيرة في كثافة المعادن في العظام بين الفقرات القطنية من نفس الجنس. **الاستنتاجات**: تشير النتائج التي توصلنا إليها إلى أن فحص كثافة المعادن في العظام في الفقرات القطنية هو طريقة أكثر فعالية وملاءمة لدراسة كثافة المعادن في العظام (BMD) للهيكل العظمي العظمي في أي موضوع، حيث تكون الفقرات L1 و L4 أكثر عرضة لهشاشة العظام من الفقرات الأخرى.

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Article citation: Ahmed RJ, Dawood NS, Al-Khalisy MH. The Relationship between Anemia and Bone Mineral Density Measured by Dual X-Ray Absorptiometry. *Al-Rafidain J Med Sci*. 2024;6(2):111-115. doi: https://doi.org/10.54133/ajms.v6i2.800

INTRODUCTION

Osteoporosis is a bony disorder characterized by a reduction in bone mineral density and mass or by alterations in bone composition and integrity. This may result in diminished bone strength, thereby elevating the susceptibility to fractures [1,2]. Fractures occur most often in the neck of the femur, spine, and wrist [3, 4]. Therefore, osteoporosis predominantly causes fractures in old women and men. Consequently, an alteration in the bone mineral density of the hip or spine can elevate the susceptibility to fractures [5]. Bone mineral density scanning is an advanced X-ray technique that offers enhanced spatial resolution, directional accuracy, rapid implementation, and minimal radiation exposure [6,7]. This is achieved

through the quick process of dual-energy X-ray absorptiometry (DEXA), making it more effective than previous methods [8,9]. The lumbar spine, hip, and femur are the most commonly chosen locations for evaluation among several other options. Representing the measurement as the absolute value of a BMD (g/cm^2) enables a straightforward comparison with previous scans to assess a patient's health history, considering age and gender [10,11]. The World Health Organization (WHO) suggests that diagnosing osteoporosis is done by defining it using the T-score, which is determined by the difference between the measured bone mineral density (BMD) and the average value of young individuals, given in standard deviations [12,13]. Anemia is a deficiency of healthy red blood cells in the body. Red blood cells deliver oxygen and nutrients to the body's tissues. Anemia can be caused by various factors, including vitamin B12 insufficiency, folate deficiency, and iron deficiency. However, iron deficiency anemia is the most prevalent kind [14,15]. The bone marrow is situated within bones and is responsible for generating all blood cell types. Typical red blood cells live for 90 to 120 days. The spleen and liver remove old blood cells [16,17]. Hemoglobin is the principle substance, which is formed of iron and globin found inside red blood cells and carries oxygen and nutrients. It adds color to red blood cells. Individuals with anemia have insufficient levels of hemoglobin. The body needs specific vitamins, minerals, and nutrients to produce an adequate amount of red blood cells. Iron, vitamin B12, and folic acid are among the most crucial nutrients [18,19]. One of the studies has established that severe iron deficiency or iron deficiency anemia negatively impacts bone health in humans, particularly in elderly men and women [20]. Other studies have shown that iron deficiency affects bone formation and resorption, resulting in changes in bone microstructure [21]. Anemia has been recognized as a significant determinant of bone health, as evidenced by the U-shaped exposure-response relationship between Hb levels and the risk of osteoporosis [22]. In conjunction with Hb levels, research has indicated that deficiencies or excesses of iron in the diet can negatively impact bone mass and mineral composition [23]. When the body has too much iron, it encourages osteoclast differentiation while stopping osteoblast proliferation and differentiation. On the other hand, not having enough iron may affect bone health by changing how vitamin D is used and how collagen is made [24,25]. The present study focuses on the effect of anemia on the BMD of lumbar vertebrae, compares BMD in different vertebrae in the lumbar region and determines which vertebrae are affected more by anemia.

METHODS

Study design and participants

The investigation had been carried out at the Outpatient Clinic of Rheumatology, Baghdad Teaching Hospital, Medical City, Baghdad, in cooperation with the College of Medicine, University of Baghdad. The study spanned from October 2023 to February 2024. By giving written consent, all participants agreed to be involved in this research. The age range of all participants included in this study was 20–45 years and they were of both sexes. They were grouped into two groups: the patient group and the control healthy subjects group. All 250 participants in the current study were exposed to hematological tests in the medical laboratory of the hospital to determine their Hb level. The patients were selected to have anemia, while control group participants (110 subjects) have a normal Hb level. The patients (95 subjects) were selected from the outpatient clinic of rheumatology. They were anemic and complained of general bone pain, specifically back pain.

Inclusion criteria

Patients with anemia and back pain are free from other illnesses such as hypertension, diabetes mellitus, hyperlipidemia, renal disease, cardiac disease, smoking, and drinking alcohol.

Measurement of BMD

All subjects involved in this research were exposed to DEXA examination to determine their BMD, mainly in the lumbar spine, using the T-score as a figure of comparison between normal and osteoporotic vertebrae.

Statistical analysis

We conducted statistical analyses using version 22 of the Statistical Package for the Social Sciences (SPSS for Windows, IBM Inc.). The differences were between control (normal: no osteoporosis and no iron deficiency) and iron deficiency with osteoporosis.

RESULTS

The participant distribution comprised 50 males and 60 females as controls, and 55 females and 40 males as patients diagnosed with anemia accompanied by bone pain. The anthropometric measurements of the participants were as follows: the mean height of males was 173.75±2.45cm and that of females was 167.85±1.85 cm; the mean weight of males was 85.5±4.55 kg and that of females was 80.95±3.75 kg (Table 1).

Table 1: distribution and anthropometric measurements of the participants in this study of the two groups (males and females)

Variable	Male	Females
Control group	50	60
Patients (anemia with bone pain)	40	55
Age (20-45 years)	38±2.5	40±3.45
Height (cm)	173.75±2.45	167.85±1.85
Weight (kg)	85.5±4.55	80.95±3.75

Values were expressed as numbers and mean±SEM.

Table 2 demonstrates a reduction in the mean BMD values in vertebrae (1, 2, 3, and 4) among females with anemia, compared to the mean BMD values of the same groups of healthy females; the same findings hold true for male cases. The mean BMD value of

vertebrae 1, 2, 3, and 4 in healthy women was 31%, 25%, 26%, and 31% lower than the mean BMD value of vertebrae 1, 2, 3, and 4 in women with anemia.

Table 2: Summarized BMD of the lumbar Vertebra in both control group and patient (anemia) of the both sexes participated in current study

Groups	L 1	L 2	L 3	L 4
Female (Control)	0.948±0.035	1.024±0.038	0.966±0.042	0.946±0.042
Female (Anemia)	0.669±0.042	0.763±0.048	0.719±0.035	0.652±0.038
Male (Control)	1.098±0.036	1.078±0.051	1.063±0.044	1.062±0.042
Male (Anemia)	0.621±0.041	0.7±0.046	0.705±0.052	0.69±0.039

Values were expressed as mean±SEM.

Conversely, the healthy men's mean BMD values for vertebras 1, 2, 3, and 4 showed a reduction of 43%, 35%, 34%, and 38%, respectively, when compared to those of men with anemia. Highly significant differences (p<0.001) were reported in the mean BMD values between the mean values of the healthy subject and the subject with anemia of both sexes (Figure 1).

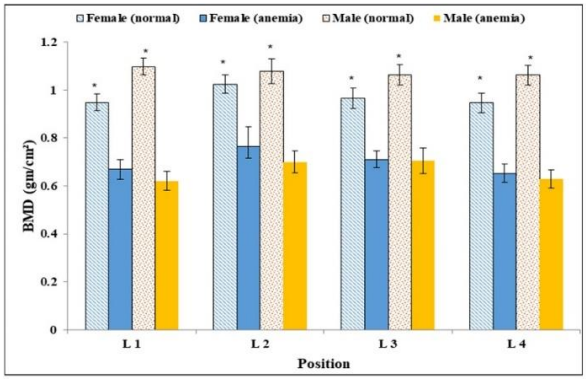

Figure 1: Comparison of the mean values of BMD for the normal subject (control) BMD and subject with anemia of the vertebrae between females and males participating in the current study. * significantly different compared to the mean value of BMD for the anemic patients within the same sex (p<0.001).

In anemia cases, the mean BMD was the lowest value of the vertebra in both of the sexes; it was 0.669 gm/cm in females and 0.0621 gm/cm in males. This study found differences in the mean BMD values of vertebra 2, 3, and 4 of females and males with anemia compared to vertebra 1 that were statistically significant (p<0.01). The differences were by 16%, 11%, and 13% for females and by 13%, 14%, and 11% for males (Figure 2).

DISCUSSION

When compared to the BMD of the control group's lumber vertebrae, the patient group (i.e., patients complaining of anemia) showed a highly significant reduction in BMD [26]. Anemia is considered a common disease that attracts the attention of researchers, according to the "National Health Statistics 2011." The bony skeleton is among the systems that anemia could potentially affect. For this reason, lumber bone mineral density was selected to highlight the role of anemia on BMD [27]. We chose to investigate the BMD of the lumber vertebrae because the thoracic vertebrae remain fixed due to their vertebrate's articulation with the ribs, which then articulate with the sternum, whereas the sacral vertebrae unite to form a single bone known as the sacrum.

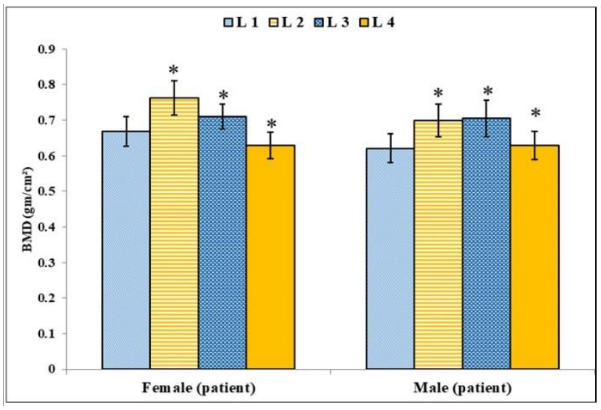

Figure 2: Comparison of the mean values of BMD for the subject with anemia of the vertebrae between females and males participating in the current study. * significantly different compared to the mean value of BMD for the vertebrae (L1) within the same sex (p<0.01).

The force of the lumber vertebrae was chosen to be studied since it is responsible for the movement of the trunk and the abandonment of body weight [28,29]. In this study, a comparison was made between the BMD of the lumber vertebrae of a healthy subject with anemia and that of a patient with backache [30]. The study revealed that the BMD of a healthy male participant's lumber vertebrae was higher than that of a healthy female participant (Figure 1). Males tend to build their bodies more robustly than females, and their more active lifestyles contribute to this increase in BMD [30]. The study showed an important finding: the BMD of lumber vertebrae was significantly lower (p<0.001) in both male and female anemia patients (Figure 2). This result aligns with previous studies conducted by other researchers [31]. Numerous explanations have been considered to account for this result. The passive effect of hypoxia, a result of anemia, impacts the health of vertebrae by elevating the acidity of the extracellular matrix and intensifying oxidative stress [32]. An impairment of vitamin D metabolism and protein production due to iron deficiency will have a negative effect on bone mineralization [33]. Because some people with anemia don't have enough iron, it affects the activation and catalysis of two important enzymes, prolyl-4 hydroxylase and lysy1-hydroxylase. These two enzymes have a crucial role in collagen synthesis [34,35]. For all the events mentioned, anemia has a passive effect on BMD. This research showed an interesting finding. Although the BMD of all lumber vertebrae was reduced in anemia patients (male and female), L1 and L4 revealed a greater reduction in BMD than that of L2 and L3 in patients of both sexes. Until now, no research has addressed or clarified this outcome. However, given that the lumber vertebrae serve as the primary component of the vertebral column responsible for trunk movement [37], it makes sense to consider L1 and L4 as the most mobile lumber vertebrae compared to the others. This is because they

articulate with the thoracic and sacrum, two immobile parts of the vertebral column. sacrum). As of now, this is merely conjecture based on the research conducted in this study, and further research is necessary to confirm or refute this concept [38].

Study limitations

The current study has many limitations including small sample size for both the patients and controls. Additionally, the study did not consider all types of anemia and did not evaluate other markers such as serum ferritin levels and blood gases.

Conclusion

Females' BMD is lower than that of males. Anemia has a passive effect on the bony skeleton's BMD. The lumbar vertebrae examination is a more suitable part of the vertebral column to study the BMD of any subject's bony skeleton. L1 and L4 vertebrae demonstrated osteoporosis more than others.

Conflict of interests

No conflict of interests was declared by the authors.

Funding source

The authors did not receive any source of fund.

Data sharing statement

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

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