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High Prevalence of Discordance in Osteoporosis Diagnosis Between Spine and Hip Bone Densitometry in Rafsanjan

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Abstract

Background: Assessing bone mineral density (BMD) at a minimum of two skeletal sites is crucial for diagnosing osteoporosis. This research aimed to examine the discordance in BMD measurements between the lumbar spine and proximal femur using dual-energy X-ray absorptiometry (DXA), along with several influencing factors.

Methods: This cross-sectional analysis included 1270 patients from the Rafsanjan BMD center in 2021. Eligible participants were at least 20 years old and possessed one or more risk factors for osteoporosis. Bone mineral density was assessed in the femoral region and the L1-L4 lumbar vertebrae using the DXA technique. Based on the T-score, values below -2.5 were classified as osteoporosis, while scores between -1 and -2.5 indicated osteopenia. The data were analyzed using SPSS 22 software, with a significance threshold of $P<0.05$ for statistical analyses.

Results: Females constituted 83.5% of the study population, with 46.9% of all participants aged between 50 and 65 years. T-score analysis revealed 48.6% (617 cases) concordance, 44.5% (565 cases) minor discordance, and 6.9% (88 cases) major discordance. According to the Z-score, the results showed 60% (762 cases) concordance, 37.5% (476 cases) minor discordance, and 2.5% (32 cases) major discordance.

Conclusion: The proportional odds model indicated that gender, age, tea consumption, residence location, and physical activity level were significant predictors affecting the likelihood of BMD discordance. Consequently, clinicians should anticipate discrepant T-score and Z-score results between the spine and hip in approximately 50% of patients.

Keywords: Osteoporosis, Bone density, Pelvic bones, Spine, Bone diseases, Metabolic

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Introduction

Osteoporosis, the most prevalent metabolic bone disorder, is characterized by a reduction in bone density and a consequent increase in bone fragility. (1) Health advances in recent decades have been accompanied by increased lifespan and life expectancy. On the other hand, industrialization and changes in lifestyles and environmental factors have caused changes in bone density. (2) There are currently 4.43 million people with osteopenia and 2.10 million with osteoporosis in the United States. Based on the current prevalence rates, projections indicate that the population over 50 with osteoporosis and osteopenia will reach 2.71 million by 2030. (3) A systematic study conducted in Iran revealed that the prevalence of osteoporosis in postmenopausal women ranged from 1.5% to 43% in the hip bones, while in the spine, it varied between 3.2% and 51.3%. The overall prevalence of osteoporosis in the hip and spine was 18.9%. (4) The prevalence of osteoporosis in males in different communities has been reported from 4% to 50%. (2)

The most important complication of osteoporosis is fracture, since in this disease, there is no warning sign until there is a fracture, and in a small number of people, osteoporosis is diagnosed at the right time. (5, 6) Complications of the disease impose a significant burden on the individual and society, and the frequency of death during the first 12 months after hip fracture is greater in men than in women. (3) The results of studies have shown that among hospitalized people, about 1-10% die due to hip fracture during the first year after fracture, and only 54% of patients develop walking abilities during the first year. (7, 8)

According to the criteria established by the World Health Organization (WHO), BMD measured by DXA serves as the definitive diagnostic tool for osteoporosis, guiding the initiation and continuation of therapeutic interventions.

In accordance with the International Society for Clinical Densitometry (ISCD) guidelines, it is necessary to measure a minimum of two skeletal sites for diagnostic and clinical decision-making purposes, using the lowest T-score obtained for the diagnosis. (9, 10) The T-score is a statistical measure that expresses a patient's BMD as the number of standard deviations above or below the average BMD of a young, healthy reference population. Based on this criterion, a value below -2.5 leads to a diagnosis of osteoporosis. A T-score ranging from -1 to -2.5 signifies a condition of osteopenia, while a T-score above -1 is considered normal. (10)

One of the problems observed in the results of the BMD test in two different sites using the DXA method is the existence of discordance and different results. T-score discordance is the difference in a person's T-score from a standard site of BMD to another measured site. (11, 12) In various studies, the rate of mild discordance between the T-scores of the hip and spine was reported to be 39% to 45.7%, while severe discordance ranged from 4.5% to 5%. (13-15) In the study by Park et al discordance of hip and spine bones BMD results based on Z-score was reported to be about 75%. (16) A common occurrence in bone densitometry is the discordance between T-scores measured at the L1-L4 lumbar spine and the hip. (13) Given the critical importance of an accurate osteoporosis diagnosis, which forms the foundation for all subsequent management and therapeutic strategies, this study was designed to determine the prevalence of discordance in bone mineral density (BMD) between the spine and hip, as measured by DXA, and several associated factors in patients referred to the Rafsanjan BMD center.

Methods

Study Design and Population

This cross-sectional study included patients referred to the Rafsanjan BMD center during 2021. From a total of 1270 clients in this period, subjects were enrolled based on the predetermined inclusion and exclusion criteria, employing a convenience sampling approach.

Inclusion and Exclusion Criteria

The eligibility criteria for participation consisted of being at least 20 years of age, men who were 70 years or above, and women aged 65 years or older, a diagnosis of hyperparathyroidism, experiencing premature menopause, a history of using 5 mg of glucocorticoids for a minimum of three months, radiographic evidence of osteopenia, and other individuals with a minimum of one of these risk factors: having a medical condition that increases the risk for osteoporosis, such as cancer, undergoing chemotherapy, low body weight, a prior fracture, and the use of high-risk medications, such as glucocorticoids, proton pump inhibitors (PPIs), selective serotonin reuptake inhibitors (SSRIs), thiazolidinediones, anticonvulsant drugs, and medroxyprogesterone acetate, as well as anticoagulants. (17) The non-inclusion criteria included dissatisfaction with participating in the study and incomplete information.

Data Collection and Anthropometric Measurements

After the study's aims were clarified, written informed consent was secured from every participant. The information regarding age, gender, education, place of residence, occupation, body mass index (BMI), smoking, history of diabetes, dyslipidemia, high blood pressure, thyroid disorders, daily calcium intake, physical activity, consuming tea (more than 4 cups per day), coffee (more than two cups per day), and dairy products was collected. Body weight was measured with a Seca scale (Germany) while participants wore light clothing and no shoes. (18) Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in meters). The BMI values were categorized into four groups: underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obese (≥ 30 kg/m²). (19)

BMD Measurement Protocol

Following a physician's examination, a trained technician measured BMD using a Stratos DXA device (IMD Generator: Vial Matteotti, 28/A 24050, Italy) at the lumbar spine (L1-L4), total hip, and femoral neck. In this method, imaging was performed without special preparation and without using significant ionizing radiation, using photons of two different energies in soft and hard tissues (bone). Some of the stronger ray is absorbed by the bone, and some of them pass through the body. The higher the bone density, the more X-rays are absorbed and the less they reach the recipient. The software output of the device reported the results of the study of a person's BMD in g/cm². (20) The measurement accuracy of this device is 2% for the density of the hip site and 1.5% for the spine site. The results of BMD were interpreted according to the WHO criteria by a specialist physician.

Based on the T-score index, which quantifies the difference from a reference mean in standard deviations, a T-score below -2.5 was classified as osteoporosis, and a T-score between -1.0 and -2.5 was defined as osteopenia (Figure 1A).

These values were calculated separately for the lumbar spine and the total hip. (21) The amount of discordance was determined based on the results of Figure 1B. T-score discordance was categorized as minor or major. Minor discordance occurs when the difference in T-score between the two sites does not exceed one WHO diagnostic category, for instance, when one site is osteoporotic and the other is osteopenic (e.g., spine T-score = -2.6, indicating osteoporosis, and hip T-score = -1.7, indicating osteopenia). Major discordance is defined as a situation where one site is normal and the other is osteoporotic

A

WHO Osteoporosis Classification System

Diagnosis	T-score
Normal	>-1.0
Osteopenia	<-1.0, >-2.5
Osteoporosis	<-2.5
Severe osteoporosis	<-2.5 plus fragility fractures

B

Classification of T-Score Discordance by Degree

Minor discordance	Major discordance
Osteopenia spine, normal hip	Normal spine, osteoporosis hip
Osteopenia hip, normal spine	Normal hip, osteoporosis spine
Osteopenia spine, osteoporosis hip	
Osteopenia hip, osteoporosis spine	

Figure 1. Classification of osteoporosis according to the WHO criteria (A) and classification of the degree of discordance between the results of BMD in the hip and spine sites (B)

(e.g., spine T-score = -2.8, indicating osteoporosis, and hip T-score = -0.9, indicating normal bone density). (13) For diagnostic interpretation and analysis of discordance, the lowest T-score value from either the femoral neck or the total hip was used to represent the hip.

Vertebral Identification and Selection Criteria for Lumbar Spine BMD

Accurate identification of vertebral levels was ensured using anatomical landmarks. L4 was aligned with the iliac crest, and L1 was typically the first vertebra below the lowest rib. In ambiguous cases, the transverse process of L3—usually the longest—was used as a reference.

According to ISCD guidelines, L1–L4 were included in the analysis unless a vertebra showed:

Artifacts (e.g., degenerative changes or fractures),

Structural abnormalities, or a T-score discrepancy > 1 SD with adjacent vertebrae.

Affected vertebrae were excluded, and BMD was averaged across three or two contiguous vertebrae. A single vertebra was not used for interpretation. (22)

Quality Control of the DXA Scanner

Daily quality control (QC) procedures were strictly followed to ensure the precision and accuracy of the DXA scanner. Upon opening the scanning software each day, a mandatory phantom scan is performed by the technician. The measured phantom value is displayed on a control chart bounded by upper and lower control limits (±2 standard deviations). If the phantom measurement falls within these limits, scanning of patients proceeds. Deviations outside this range may be due to 1. unstable environmental conditions such as humidity or temperature fluctuations, 2. operator error in phantom positioning, or 3. device calibration issues requiring technical inspection.

The coefficient of variation (CV) for repeated phantom scans was maintained within an acceptable range (e.g., 1-2%). All technicians performing the scans were certified and trained according to standard protocols to minimize operator-related variability.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, Version 22. Statistical tests, including the Chi-square test, McNemar test, gamma coefficient, Kappa coefficient, and proportional odds model, were employed to address the research questions. All statistical analyses used a significance level of $P < 0.05$.

To test the validity of the proportional odds model, the proportional odds assumption was tested. It is an assumption that odds ratios across levels of the dependent variable are the same (parallel) for all predictor variables' levels. To check whether it is true or not, the Brant test was performed with the help of an integrated R extension package on SPSS. The result of the Brant test indicated that the assumption of proportional odds held true for the data in question ($\chi^2 = 5.32$, $P > 0.05$). Specifically, the *P*-value of 0.732 demonstrated that the assumption held, which rendered it acceptable to employ the use of the proportional odds model in the analysis.

The Chi-square test was employed to assess associations between categorical variables. The strength and direction of the relationship between ordinal variables were evaluated using the Gamma coefficient, while the Kappa coefficient measured inter-rater reliability. The McNemar test was used for analyzing paired nominal data. Proportional odds regression was applied to estimate the ordinal outcome variable, adjusting for predictor variables' effects while retaining the assumption of proportional odds being tested.

Ethical Code: Informed consent was obtained from all participants before their enrollment in the study, and the research protocol received approval from the local ethics committee (Ethical code: IR.RUMS.REC.1399.206).

Results

In the present study, 1270 patients referred to the Rafsanjan BMD center were examined. Table 1 reveals the results of demographic variables. The study population was predominantly female (83.5%), with nearly half (46.9%) aged between 50 and 65 years. The majority of participants were illiterate (72.6%), unemployed (72.6%), and resided in urban areas (70.4%). In terms of the history of previous disease, high blood pressure had the highest frequency (38.2%), and history of thyroid disease had the lowest frequency (5.7%).

Table 1. Frequency distribution of demographic and clinical variables in patients referred to Rafsanjan BMD center in 2021

Variables	Number	%
Gender		
Male	209	16.5
Female	1061	83.5
Age groups		
20-35 years	23	1.8
35-50 years	276	21.7
50-65 years	595	46.9
65-80 years	322	25.4
Over 80 years	54	4.3
Education		
Illiterate	922	72.6
High school	107	8.4
Academic	241	19.0
Occupation		
Unemployed	922	72.6
Self-employed	407	8.4
Government job	241	19.0
Place of residence		
City	894	70.4
Village	376	29.6
BMI (kg/m^2)		
Less than 18.5	24	1.9
18.5 to 24.9	208	16.4
25 to 29. 9	500	39.4
Above 30	538	42.3
History of diabetes (yes)	298	23.5
History of dyslipidemia (yes)	325	25.6
History of high blood pressure (yes)	491	38.2
History of thyroid disease (yes)	72	5.7
Daily calcium intake (yes)	408	22.1
Physical activity (yes)	178	14.0
Tea consumption (yes)	1077	84.8
Coffee consumption (yes)	143	11.3
Dairy consumption (yes)	1081	85.1
Total	1270	100

Table 2 presents the concordance and discordance between hip and spine BMD results based on T-scores and Z-scores. The analysis using T-scores revealed a concordance rate of 87% for normal diagnoses, 48.9% for osteopenia, and 26.2% for osteoporosis ($P<0.001$). The kappa coefficient was 0.261, suggesting weak agreement in osteoporosis diagnosis between the hip and spine based on T-score ($P=0.018$).

According to the Z-score, the concordance of diagnosing normal cases was 93.8%, the concordance of diagnosing osteopenia was 25.7%, and the concordance of diagnosing osteoporosis was 7.9% ($P<0.001$). The kappa coefficient was 0.202, reflecting a weak level of agreement in diagnosing osteoporosis between the hip and spine when using the Z-score ($P=0.020$).

The analysis of concordance and discordance revealed that, based on the T-score, 48.6% (n = 617) of cases showed concordance, 44.5% (n = 565) exhibited minor discordance, and 6.9% (n = 88) demonstrated major discordance. When using the Z-score, 60% (n = 762) of cases were concordant, 37.5% (n = 476) showed minor discordance, and 2.5% (n = 32) had major discordance. Table 3 reveals the results related to the type of concordance based on demographic and underlying variables.

The comparison of T-score concordance and discordance levels revealed that the highest rate of concordance was found in patients over 80 years of age ($P=0.013$). Also, the type of concordance was significantly different according to the history of thyroid disease ($P=0.021$) and physical activity ($P=0.007$). This distribution pattern differed when assessed by Z-score in the population aged over 80 years ($P=0.006$) and people with BMI above 30 kg/m^2 ($P=0.002$) had the highest percentage of mild discordance. The type of concordance was significantly different in terms of tea consumption ($P=0.014$) and dairy consumption ($P=0.039$).

The results of predictive factors for the existence of discordance in the hip and spine BMD based on the T-score using the proportional odds model indicated that gender, age group, place of residence, and physical activity significantly altered the odds of discordance. The higher odds ratio of discordant results was observed in males

Table 2. Concordance and discordance between the results of the hip bones and spine BMD based on the T-score and Z-score

Pelvis \ Spine	Normal	Osteopenia	Osteoporosis	Mc-Nemar Test statistics	Mc-Nemar *P* value	Gamma Test statistics	Gamma *P* value
Based on the T-score							
Normal	257(87.0)	40(12.7)	1(0.3)	428.5	<0.001	0.778	<0.001
Osteopenia	183(45.2)	198(48.9)	24(5.9)				
Osteoporosis	87(15.9)	318(57.9)	122(26.2)				
Based on the Z-Score							
score Normal	621(93.8)	41(6.2)	0(0)	328.4	<0.001	0.738	<0.001
Osteopenia	383(73.9)	133(25.7)	2(0.4)				
Osteoporosis	32(36.0)	50(56.2)	7(7.9)				

Table 3. Frequency distribution of concordance and discordance between the results of the hip bones and spin BMD based on the T-score and Z-score in terms of demographic and underlying variables

Variables	T-score			*P* value	Z-score			*P* value
	Concordance	Mild discordance	Severe discordance		Concordance	Mild discordance	Severe discordance	
Gender								
Female	526(49.6)	466(43.9)	69(6.5)	0.177	646(60.9)	389(36.7)	26(2.5)	0.348
Male	91(43.5)	99(47.4)	19(9.1)		116(55.5)	87(41.6)	6(2.9)	
Age groups								
20-35 years	14(60.9)	9(39.1)	0(0)		14(60.9)	9(39.1)	0(0)	
35-50 years	136(49.3)	129(46.7)	11(3.0)	0.013	162(58.7)	111(40.2)	3(1.1)	0.006
50-65years	266(44.7)	278(46.7)	51(8.6)		334(56.1)	237(39.8)	24(4.0)	
65-80years	165(51.2)	134(41.6)	23(7.1)		212(65.8)	105(32.6)	5(1.6)	
Over 80 years	36(66.6)	15(27.8)	3(5.6)		40(74.1)	14(25.9)	0(0)	
Diabetes	146(49.0)	136(45.6)	16(5.4)	0.437	178(59.7)	110(3.4)	10(3.4)	0.572
High blood fats	159(48.9)	138(42.5)	28(8.6)	0.331	191(58.8)	123(37.9)	11(3.4)	0.495
High blood pressure	245(49.9)	208(42.4)	38(7.7)	0.419	298(60.7)	176(35.9)	17(3.5)	0.175
Thyroid	29(40.3)	42(58.3)	1(1.4)	0.021	42(58.3)	28(38.9)	2(2.8)	0.951
Calcium intake	190(46.6)	191(46.8)	27(6.6)	0.518	238(58.3)	160(39.2)	10(2.5)	0.680
BMI (kg/m^2)								
Less than 18.5	18(75.0)	6(25.0)	0(0)		23(95.8)	1(4.2)	0(0)	
18.5 to 24.9	106(51.0)	87(41.8)	15(7.2)	0.175	133(63.9)	70(33.7)	5(2.4)	0.002
25 to 29. 9	231(46.2)	234(46.8)	35(7.0)		303(60.6)	189(37.8)	8(1.6)	
Above 30	262(48.7)	238(44.2)	38(7.1)		303(56.3)	216(40.1)	19(3.5)	
Physical activity	103(57.9)	70(39.3)	5(2.8)	0.007	106(59.6)	64(36.0)	8(4.5)	0.188
Tea consumption	521(48.4)	488(45.3)	68(6.3)	0.082	628(58.3)	420(39.0)	29(2.7)	0.014
Coffee consumption	70(49.0)	64(44.8)	9(6.3)	0.951	76(53.2)	63(44.1)	4(2.8)	0.205
Dairy consumption	524(48.5)	488(45.1)	69(6.4)	0.146	633(58.6)	419(38.8)	29(2.7)	0.039

compared to females, the age group of 50 to 65 years compared to the age group of 80 to 95 years, residents in the city compared to residents in the village, and those who were not physically active (Table 4).

The analysis of predictive factors for discordance in hip and spine BMD using Z-scores via the Proportional Odds Model revealed that age group, weight, and tea consumption significantly affected the odds of discordance. Higher odds of discordant results were found in the 50 to 65 age group compared to the 80 to 95 age group, as well as among individuals with greater body weight and those who consumed tea (Table 5).

Discussion

The diagnosis of osteoporosis is made by measuring bone mass using DXA. Given the fact that in this method, bone density is measured in a simple and non-invasive way, in a short time, and by receiving low radiation levels, it is regarded as the definitive method for diagnosing osteoporosis. The DXA method can be utilized to assess bone mineral density in the vertebral column, hip, and peripheral skeletal sites. (23) Discordance between T-scores from the spine and hip is a frequent occurrence in bone densitometry, where an individual's T-score differs between these anatomical sites. (13) The findings of this investigation revealed that the overall concordance between hip and spine BMD measurements was 48.6% when based on T-scores and 60% when based on Z-scores, which, according to the kappa coefficient, it was a weak concordance. The investigation conducted by Pacheco et al revealed that the sensitivity for diagnosing osteoporosis using T-scores at the femoral neck and hip sites was 36.4% and 58.8%, respectively, and at the spine site was 21.8%. (24) In another study, the sensitivity and specificity of diagnosing osteoporosis using DXL Calscan in axial sites were reported to be 80% and 82%, respectively. (25) Nelson et al reported a 3.5% prevalence of discordance between hip and spine bone densitometry results. (26) The research conducted by Park et al indicated that Z-score discordance was reported 75% in vertebrae of the spine and 73.8% in femur neck, respectively (16), which is consistent with the general patterns observed in Young et al (27) and Hwang et al (28). The discordance between densitometry results observed in the present study indicates the inherent weakness of any diagnostic system relying on standard and sometimes strict guidelines. (13) Other reasons for the discordance in densitometry results include physiological and genetic causes in the reduction

Table 4. Factors affecting the discordance in the results of the hip bones and spin BMD based on the T-score *

Variables	Unadjusted			Adjusted		
	OR	95% CI for OR	*P*-value	OR**	95% CI for OR	*P* value
Gender Males compared to females	1.335	0.987-4.161	0.061	1.412	1.040-1.917	0.027
Age groups (year) (Reference 80-95 years)						
20 to 35 years	1.418	0.483-4.161	0.123	1.597	0.535-4.770	0.098
35 to 50 years	1.841	1.004-3.377	0.045	1.484	0.997-3.424	0.052
50 to 65 years	2.442	1.365-4.370	0.008	2.551	1.416-4.594	0.006
65 to 80 years	1.945	1.066-3.547	0.032	1.939	1.058-3.554	0.029
Place of residence City compared to village	1.392	1.089-1.779	0.008	1.481	1.150-1.906	0.002
Physical activity	0.639	0.462-0.882	0.007	0.568	0.407-0.793	0.001

OR: Odds ratio, CI: Confidence interval.
*Input variables of the model: gender, age group, weight, height, place of residence, education, Fx. patient, physical activity, tea consumption, dairy consumption, hypothyroidism, and duration of menopause.
**Given that the sample size is large, the variables that had a *P*-value≤0.20 in Univariate analysis were included in the Multivariable model. In Univariate tests, between the Chi-square test and the Chi-square test for trend, whichever had a lower *P*-value was considered. In cases where the necessary conditions for performing the Chi-square test were not met, the *P*-value of Fisher's exact test was considered.

Table 5. Factors affecting the discordance in the results of the hip bones and spine BMD based on the Z-score*

Variables	Unadjusted			Adjusted		
	OR	95% CI for OR	*P* value	OR**	95% CI for OR	*P* value
Age groups (year) (Reference 80-95 years)						
20 to 35 years	2.210	0.731-6.685	0.078	2.010	0.661-6.112	0.094
35 to 50 years	2.095	1.086-4.040	0.027	1.851	0.953-3.598	0.036
50 to 65 years	2.351	1.249-4.424	0.012	2.167	1.146-4.099	0.017
65 to 80 years	1.471	0.764-2.833	0.108	1.393	0.720-2.694	0.132
Weight	1.014	1.005-1.022	0.001	1.012	1.004-1.021	0.004
Tea consumption	1.636	1.170-2.287	0.004	1.546	1.102-2.168	0.012

OR: Odds ratio, CI: Confidence interval.
*Input variables of the model: gender, age group, weight, height, place of residence, education, Fx. patient, physical activity, tea consumption, dairy consumption, hypothyroidism, and duration of menopause.
**Given that the sample size is large, the variables that had a *P*-value≤0.20 in Univariate analysis were included in the Multivariable model. In Univariate tests, between the Chi-square test and the Chi-square test for trend, whichever had a lower *P*-value was considered. In cases where the necessary conditions for performing the Chi-square test were not met, the *P*-value of Fisher's exact test was considered.

of bone mineral density at both the lumbar spine and hip, pathophysiological factors, such as diseases affecting bone mass, anatomical reasons that cause differences in the proportion of cortical to trabecular bone and the rate of bone loss. (11, 14) Moreover, technical error can also cause different results for various reasons, such as insufficient radiologist's skills or lack of calibration of the equipment. (29)

According to the findings of this study, T-score analysis revealed 44.5% minor discordance and 6.9% major discordance, while Z-score analysis showed 37.5% minor discordance and 2.5% major discordance. In this context, Woodson reported T-score concordance of 56%, with 39% minor discordance and 5% major discordance between hip and spine measurements. T-score results also indicated minor discordance between hip and spine measurements in 40% of patients undergoing DXA scans, and although severe discordance was uncommon, this was observed in 5% of the patients. (13) In another study, about 75% of discordance between hip and spine bones densitometry results was reported based on the Z-score. (16) Mounach et al reported concordance in 49.4% of cases, minor discordance in 45.7%, and major discordance in 4.8% of cases. (14) Afzal et al reported that there was concordance in 56.5% of patients, mild discordance in 39%, and severe discordance in 4.5% of patients. (15) Discordance in hip and spine bones densitometry results has been reported as a common phenomenon in studies and should be considered as a real finding, since due to the mentioned causes, the process of bone loss in a site may occur less or more slowly and therefore different diagnostic categories—normal bone density, osteopenia, and osteoporosis—are observed in the densitometry of the two sites. The results of studies have shown that when severe discordance is observed, the occurrence probability of osteoporotic pattern in the hip bones and normal pattern in the spine site is twice that of the occurrence of osteopenic pattern in the vertebrae of the spine and normal pattern in the hip bones. One of the reasons for such a difference is the different bone density as a result of pathophysiological factors affecting the vertebrae of the spine. (30, 31)

Finally, the findings of this investigation demonstrated that the rate of concordance varies significantly with age, history of thyroid disease, physical activity levels, body mass index, and consumption patterns of tea and dairy products. The results of examining the odds ratio of the discordance in the results also showed the effect of male gender, age, living in a city, physical activity, higher weight, and tea consumption. The investigation by Park et al demonstrated that reduced body mass index, vitamin D deficiency, and decreased muscle mass were all correlated with diminished bone mass. (16) Eastell et al reported that various factors, such as smoking, high alcohol consumption, glucocorticoid use, chronic diseases, and low weight, were the factors affecting bone mass. (32) Chan et al identified advanced age, height loss, and physical activity level as factors contributing to T-score discordance in bone densitometry. (33) Moayyeri et al examined the factors affecting the discordance in the T-score results and reported that old age, female gender, and menopause were effective in this regard. (11) Research has demonstrated that common causes of secondary osteoporosis, including glucocorticoid use, hyperthyroidism, malabsorption syndromes, hepatic disorders, rheumatoid arthritis, and certain medications, predominantly affect trabecular bone and consequently the spine, resulting in a higher incidence of spinal osteoporosis. (34) The association between T-score discordance and age stems from variations in bone mineral density measurements between the spine and hip during specific life stages, which increases over time due to bone mass loss. The existence of discordance according to BMI can be due to the fact that more weight bearing might increase bone mass and thus create discordance in the BMD results. The research conducted by Shayganfar et al revealed that higher body mass index was associated with greater bone mass and a decreased risk of bone fractures. It was also observed that bone mineral density in the lumbar spine and femoral neck was greater in individuals with a body mass index exceeding 30 compared to those with a BMI below 25, and that bone mass declined with advancing age. (35)

The strength and power of this study is the high number of the study population (1270 people), which increases the validity of our study.

Our investigation, similar to other cross-sectional studies, has several limitations. The study population consisted of individuals who were either referred from other healthcare centers for osteoporosis evaluation or visited the BMD center for routine check-ups. This convenience sampling method may have introduced selection bias, as these participants may differ from the general population of Rafsanjan in terms of socioeconomic status, education level, and the prevalence of osteoporosis-related risk factors, including tobacco use and alcohol consumption. Consequently, the applicability of these findings to the general population is restricted. However, including a diverse group of patients with different referral reasons may increase the internal validity of our study by reflecting real-world clinical settings. Another limitation of this study is that vertebrae were not assessed or excluded based on structural abnormalities, degenerative changes, aortic calcification, or T-score discrepancies between adjacent vertebrae. Instead, BMD classification was based solely on the WHO criteria. This approach may have resulted in overestimation of lumbar spine BMD in some participants. Future research should consider applying the ISCD guidelines to exclude affected vertebrae and improve the accuracy of spinal BMD assessment.

Conclusion

The discordance between the spine and hip bones' densitometry results in the present study was high. Consequently, clinicians should anticipate that approximately 50% of patients undergoing DXA BMD testing will demonstrate discordance between T-scores and Z-scores at the spine and hip sites. This discordance may be influenced by multiple factors, including age, body mass index, comorbid conditions, and physical activity levels.

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Competing Interests

The authors declare that they have no conflicts of interest.

Data Availability

The data are not available publicly. However, upon a reasonable request, the data can be obtained from the corresponding author.

Ethical Approval

The informed consent form was signed by the participants before entering into the project, and the project protocol was approved by the local ethical committee (Ethical code: IR.RUMS.REC.1399.206). This study was conducted in compliance with the guidelines of the Declaration of Helsinki.

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References

1. Raisz LG. Pathogenesis of osteoporosis: concepts, conflicts, and prospects. J Clin Invest. 2005;115(12):3318-25. doi: 10.1172/jci27071
2. Hosseinnezhad A, Soltani A, Adibi H, Hamidi Z, Maghbooli Z, Larijani B. Relationship between life style and bone mineral density in men. Zahedan J Res Med Sci. 2003;5(1):13-20. [Persian].
3. Dempster DW. Osteoporosis and the burden of osteoporosis-related fractures. Am J Manag Care. 2011;17 Suppl 6:S164-9.
4. Bagheri P, Haghdoost AA, Dortaj Rabari E, Halimi L, Vafaei Z, Farhangnia M, et al. Ultra-analysis of prevalence of osteoporosis in Iranian women "a systematic review and meta-analysis". Iran J Endocrinol Metab. 2011;13(3):315-25. [Persian].
5. Varacallo MA, Fox EJ. Osteoporosis and its complications. Med Clin North Am. 2014;98(4):817-31. doi: 10.1016/j.mcna.2014.03.007
6. Davies L, Berridge D, Lyons J, Walters A, Lyons RA. Cohort study of osteoporosis and fracture risk: are we achieving benefit with secondary prevention? Inj Prev. 2016;22(Suppl 2):A178. doi: 10.1136/injuryprev-2016-042156.493
7. Keene GS, Parker MJ, Pryor GA. Mortality and morbidity after hip fractures. BMJ. 1993;307(6914):1248-50. doi: 10.1136/bmj.307.6914.1248
8. Malik AT, Panni UY, Masri BA, Noordin S. The impact of surgeon volume and hospital volume on postoperative mortality and morbidity after hip fractures: a systematic review. Int J Surg. 2018;54(Pt B):316-27. doi: 10.1016/j.ijsu.2017.10.072
9. Bover J, Bailone L, López-Báez V, Benito S, Ciceri P, Galassi A, et al. Osteoporosis, bone mineral density and CKD-MBD: treatment considerations. J Nephrol. 2017;30(5):677-87. doi: 10.1007/s40620-017-0404-z
10. Silva DM. Diagnosis of osteoporosis; bone mineral density, risk factors, or both? EC Orthop. 2018;9(7):500-2.
11. Moayyeri A, Soltani A, Khaleghnejad Tabari N, Sadatsafavi M, Hossein-Neghad A, Larijani B. Discordance in diagnosis of osteoporosis using spine and hip bone densitometry. BMC Endocr Disord. 2005;5(1):3. doi: 10.1186/1472-6823-5-3
12. Xu XM, Li N, Li K, Li XY, Zhang P, Xuan YJ, et al. Discordance in diagnosis of osteoporosis by quantitative computed tomography and dual-energy X-ray absorptiometry in Chinese elderly men. J Orthop Translat. 2019;18:59-64. doi: 10.1016/j.jot.2018.11.003
13. Woodson G. Dual X-ray absorptiometry T-score concordance and discordance between the hip and spine measurement sites. J Clin Densitom. 2000;3(4):319-24. doi: 10.1385/jcd:3:4:319
14. Mounach A, Mouinga Abayi DA, Ghazi M, Ghozlani I, Nouijai A, Achemlal L, et al. Discordance between hip and spine bone mineral density measurement using DXA: prevalence and risk factors. Semin Arthritis Rheum. 2009;38(6):467-71. doi: 10.1016/j.semarthrit.2008.04.001
15. Afzal U, Syed GS, Bashir H, Dakker MO. Frequency of discordance between spine and hip T-score determined on dual X-ray absorptiometry (DXA). Pak J Radiol. 2016;26(2):70-6.
16. Park KH, Lim JS, Kim KM, Rhee Y, Lim SK. Z-score discordance and contributing factors in healthy premenopausal women with low bone mineral density: the Korean National Health and Nutrition Examination Survey 2008-9. J Bone Miner Metab. 2016;34(6):668-77. doi: 10.1007/s00774-015-0715-x
17. Panday K, Gona A, Humphrey MB. Medication-induced osteoporosis: screening and treatment strategies. Ther Adv Musculoskelet Dis. 2014;6(5):185-202. doi: 10.1177/1759720x14546350
18. Poustchi H, Eghtesad S, Kamangar F, Etemadi A, Keshtkar AA, Hekmatdoost A, et al. Prospective epidemiological research studies in Iran (the PERSIAN Cohort Study): rationale, objectives, and design. Am J Epidemiol. 2018;187(4):647-55. doi: 10.1093/aje/kwx314
19. Centers of Disease Control and Prevention. Healthy Weight, Nutrition, and Physical Activity. Available from: https://www.cdc.gov/healthyweight/index.html/.
20. Mola K, Cheraghi M, Jaferian S, Mosadegh AA. Evaluation of bone mass density in healthy individuals in Ahvaz (2000-2003). Yafteh. 2007;8(4):19-24. [Persian].
21. Kanis JA. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: synopsis of a WHO report. WHO Study Group. Osteoporos Int. 1994;4(6):368-81. doi: 10.1007/bf01622200
22. International Society for Clinical Densitometry (ISCD). 2023 ISCD Official Positions Adult. Available from: https://iscd.org/wp-content/uploads/2024/03/2023-ISCD-Adult-Positions.pdf.
23. Dondelinger R. The fundamentals of...bone densitometry. Biomed Instrum Technol. 2014;48(4):295-9. doi: 10.2345/0899-8205-48.4.295
24. Pacheco EM, Harrison EJ, Ward KA, Lunt M, Adams JE. Detection of osteoporosis by dual energy X-ray absorptiometry (DXA) of the calcaneus: is the WHO criterion applicable? Calcif Tissue Int. 2002;70(6):475-82. doi: 10.1007/s002230020030
25. Kullenberg R, Falch JA. Prevalence of osteoporosis using bone mineral measurements at the calcaneus by dual X-ray and laser (DXL). Osteoporos Int. 2003;14(10):823-7. doi: 10.1007/s00198-003-1442-z
26. Nelson DA, Molloy R, Kleerekoper M. Prevalence of osteoporosis in women referred for bone density testing: utility of multiple skeletal sites. J Clin Densitom. 1998;1(1):5-11. doi: 10.1385/jcd:1:1:5
27. Young M, Birch N. Prevalence of major and minor discordance between hip and spine t scores using rems: implications for bone health assessment and patient management. Orthop Proc. 2023;105(Suppl 16):46. doi: 10.1302/1358-992x.2023.16.046
28. Hwang HJ, Park SY, Lee SH, Han SB, Ro KH. Differences in bone mineral density between the right and left hips in postmenopausal women. J Korean Med Sci. 2012;27(6):686-90. doi: 10.3346/jkms.2012.27.6.686
29. Lu YC, Lin YC, Lin YK, Liu YJ, Chang KH, Chieng PU, et al. Prevalence of osteoporosis and low bone mass in older Chinese population based on bone mineral density at multiple skeletal sites. Sci Rep. 2016;6:25206. doi: 10.1038/srep25206
30. Rand T, Seidl G, Kainberger F, Resch A, Hittmair K, Schneider B, et al. Impact of spinal degenerative changes on the evaluation of bone mineral density with dual energy X-ray absorptiometry (DXA). Calcif Tissue Int. 1997;60(5):430-3. doi: 10.1007/s002239900258
31. Reid IR, Evans MC, Ames R, Wattie DJ. The influence of osteophytes and aortic calcification on spinal mineral density in postmenopausal women. J Clin Endocrinol Metab. 1991;72(6):1372-4. doi: 10.1210/jcem-72-6-1372
32. Eastell R. Prevention and management of osteoporosis. Medicine. 2017;45(9):565-9. doi: 10.1016/j.mpmed.2017.06.004
33. Chan CY, Subramaniam S, Mohamed N, Ima-Nirwana S, Muhammad N, Fairus A, et al. Prevalence and factors of T-score discordance between hip and spine among middle-aged and elderly Malaysians. Arch Osteoporos. 2020;15(1):142. doi: 10.1007/s11657-020-00821-5
34. Aaron JE, Johnson DR, Paxton S, Kanis JA. Secondary osteoporosis and the microanatomy of trabecular bone. Clin Rheumatol. 1989;8 Suppl 2:84-8. doi: 10.1007/bf02207240
35. Shayganfar A, Ebrahimian S, Masjedi M, Daryaei S. A study on bone mass density using dual energy X-ray absorptiometry: does high body mass index have protective effect on bone density in obese patients? J Res Med Sci. 2020;25:4. doi: 10.4103/jrms.JRMS_1066_18