T-Score Discordance Between Hip and Spine in Diagnosis of Osteoporosis in Patients From Iranian Population

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Abstract- Today, osteoporosis is a major healthcare system problem globally. Each year, osteoporosis leads to more than 8.9 million fractures. In practice, osteoporosis can be diagnosed following a low-energy trauma fragility fracture of a bone or by a bone mineral density measurement using dual X-ray absorptiometry showing a T-score of ≤-2.5. This is a retrospective study that reviewed all subjects with osteoporosis or osteopenia indication, which were referred by practitioners for diagnostic densitometric evaluation to Alzahra hospital in Isfahan, Iran. from January 1, 2017, to December 31, 2019. Bone mineral density (BMD) reports were reviewed to identify all cases of osteoporosis or osteopenia. Our data analysis according to the World Health Organization (WHO) diagnostic classification showed that simultaneously measured T-scores at the spine and hip are concordant in 49.60% of patients and discordant by at least one diagnostic class in 49.95%. There was no significant discordance prevalence when one site was osteoporotic, and another site was normal (The prevalence was only 4.74%). Major T-score discordance was directly correlated to age (r=0.908, *P*=0.005), but there was no statistical relationship between minor T-score discordance and age (*P*=0.07). Clinicians should expect that at least half of patients tested by DXA will demonstrate T-score discordance between spine and total hip measurement sites. However, discordance is a real finding, and clinicians should be familiar with this issue and adopt specific strategies for these patients to investigate the cause or causes of the discordance.

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Introduction

Today, despite scientific advances, Osteoporosis (OP) is a major healthcare system problem globally. Each year, osteoporosis leads to more than 8.9 million fractures. It is estimated that one-third of women and one-fifth of men older than 50 will experience an OP fracture. Each year, OP fractures lead to a worldwide loss of 5.8 million healthy life years to disability. Four out of ten individuals cannot walk independently after a hip fracture, and 80% cannot perform basic activities such as shopping independently. 10-20% of hip fracture sufferers require permanent nursing home care after the incident. In women older than 45, OP is responsible for more admits to the hospital than diabetes, heart attacks, or breast cancer (1,2). The burden of OP is more than 37 billion euros annually in the European nations at this time (3).

One-fifth to one-fourth of hip fractures occur in men. The survival rate of individuals with osteoporotic hip fractures is 20% in the first year, and this survival is lower in men than women (4). Lifetime risk of experiencing OP fracture in men older than 50 years (27%) is more than developing prostate cancer (11.3%) (5). Hip fractures are more common in women than men, but fracture-related mortality is higher in men (6). Mortality after OP hip fracture in the first year after a fracture is highest and increases in both genders with age (7). The mortality rate of men is approximately doubled in the first months compared to similarly aged women (8,9). In aging men, wrist fractures show a higher risk for hip OP fracture than vertebral fractures compared to women. Thus this evidence shows that forearm fractures are an early and

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sensitive marker for male skeleton susceptibility to fracture (10).

Rickets has the highest prevalence among Middle East residents despite the high amount of sunshine. Vitamin D deficiency is common among residents of this region (11).

Death rate after OP hip fracture might be higher in the Middle East than in western nations; while such a rate is between 25 to 30 percent in western populations, the Middle East and African region may have a 2-3-fold higher mortality rate.

The country of Iran is responsible for 0.85% and 12.4% of the global and Middle East burden of hip fractures. Osteopenia prevalence is estimated at around 34% of the total population of Iran at the moment, according to Endocrinology and Metabolism Research Center (EMRC). In Iran, more than 2 million individuals are at risk of fracture, and developing osteoporosis is one of the most concerning healthcare system problems in Iran (11).

OP is defined as 'systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture risk' according to a development conference in 1991 (12).

The World Health Organization defined osteoporosis as BMD≥2.5 SD below the mean for healthy young women at any site of the body (Spine, hip, or wrist). This fracture threshold is a cut-off that would include most of the individuals at risk or patients who had osteoporotic fractures (13).

OP is diagnosed by practitioners with a low-energy trauma fragility fracture or with a BMD showing a T-score of ≤-2.5 using dual X-ray absorptiometry (DXA). DXA is a gold standard method for measuring BMD with high sensitivity (14).

BMD measurements are widely used to diagnose and assess the severity of OP in the clinical setting (4).

Exact values of the BMD (g/cm2) are not used routinely for OP diagnosis, but BMD according to T-score is used for diagnosis. T- score is the difference between the measured BMD and the mean value of young adults of the normal population of the same ethnicity (15).

This definition is currently applied globally despite its limitations, So the WHO criteria for OP define Op as a T-Score below -2.5 and osteopenia defined as T-score between -2.5 and -1. BMD is usually calculated separately for the lumbar spine and total hip.

Various studies have analyzed the prevalence and impact of T-score discordance on the management of osteoporosis (14), and a few studies focused on risk factors of this commonly observed discordance (4). The purpose of this study was to investigate the prevalence of discordance in the diagnosis of osteoporosis using spine and hip bone densitometry in patients referred to Al-Zahra hospital from 2017 to 2019.

Materials and Methods

The current study is a retrospective study that reviewed all subjects with osteoporosis or osteopenia indication, which were referred by clinicians for diagnostic densitometry evaluation to Alzahra hospital in Isfahan, Iran, from January 1, 2017, to December 31, 2019. BMD reports were reviewed to identify all cases with osteoporosis or osteopenia that were examined for this study. A total of 3780 cases that underwent bone mineral densitometry by DXA were reviewed. This study was revived and approved by the Isfahan University of Medical Sciences.

The following data were collected on each subject, including age, sex, history of corticosteroid treatments, underlying diseases, smoking, low weight, menopausal age, history of trauma, and BMD. Data collection was supervised by a rheumatologist expert. The collected data were summarized and analyzed using SPSS-24 software. The analysis included descriptive and inferential methods; t-test and ANOVA, a bivariate general linear model (GLM) was used for quantitative variables, and multinomial logistic regression and chi-square test for qualitative variables. Data were expressed based on mean, standard deviation, number (percentage), odds ratio, and 95% confidence interval. *P* less than 0.05 were considered statistically significant.

Results

Overall, the majority was female (89.05%), 50-59 years old (36.22%). Most people in this study (39.48%) had a body mass index of 25-30 kg/m2. Diabetes (13.06%) and autoimmune diseases (12.49%) were the most common chronic underlying diseases. Also, the most prevalent risk factors for osteoporosis were corticosteroids, and low weight, 17.22%, and 10.58%, respectively (Table 1).

In this study, the mean T-score of the hip was -1.83 (95% Confidence interval -1.87 to -1.94), and the median was -1.94. The right skewness equal to 0.51 indicates the T-score of the hip has an approximately normal distribution. The mean T-score of the spine was -1.14 (95% CL-1.14 to -1.02), and the median was -1.13. The left skewness equal to -21.0 indicates the T-score of the

spine has no normal distribution. Figure 1 compares the frequency of the T-score between the hip and spine.

Current study analysis demonstrated that according to the WHO classification system, T-scores at the spine and hip are concordant in the 49.6% of participants who were referred to our hospital. On the other hand, 49.95% of participants showed discordance by at least one diagnostic class.

Minor discordance (Only one WHO diagnostic class difference) was found to be common in our sample, with a 45.21% prevalence. On the other hand, major discordance (One site osteoporotic while another site is normal) was rare with low prevalence (4.74%).

Table 1. Summary of some characteristics and risk factors of subjects

Characteristics		Gender		
		Male	Female	Total
		n=414(10.95)	n=3366(89.05)	N=3780(100.00)
Age, y	20-29	25(6.04)	38(1.13)	63(1,67)
	30-39	44(10.63)	207(6.15)	251(6.64)
	40-49	67(16.18)	593(17.62)	660(17.46)
	50-59	91(21.98)	1219(36.22)	1310(34.66)
	60-69	93(22.46)	913(27.12)	1006(26.61)
	70-79	64(15.46)	332(9.86)	396(10.48)
	80≤	30(7.25)	64(1.90)	94(2.49)
BMI, Kg/m^2	18.5>	16(3.86)	41(1.22)	57(1.51)
	18.5-25	177(42.75)	762(22.64)	939(24.84)
	25.1-30	139(33.57)	1341(39.84)	1480(39.15)
	30<	74(17.87)	1188(35.29)	1262(33.39)
	Unknown	8(1.93)	34(1.01)	42(1.11)
Underlying chronic disease	Diabetes	53(12.80)	461(13.70)	514(13.60)
	Hypothyroid disease	21(5.07)	342(10.16)	363(9.60)
	Autoimmune disease	51(12.32)	421(12.51)	472(12.49)
	Chronic Liver Disease	23(5.56)	20(0.59)	43(1.14)
	Chronic kidney Disease	20(4.83)	42(1.25)	62(1.64)
	Corticosteroids treatments	109(26.33)	542(16.10)	651(17.22)
Some risk factors	Low weight	34(8.21)	366(10.87)	400(10.58)
	History of fracture due to trauma	21(5.07)	144(4.28)	165(4.37)
	History of Hip fracture	15(3.62)	126(3.74)	141(3.73)
	Current smoker	40(9.66)	6(0.18)	46(1.22)
	Total	387(93.48)	2470(73.38)	2857(75.58)

Data are presented as n (%)

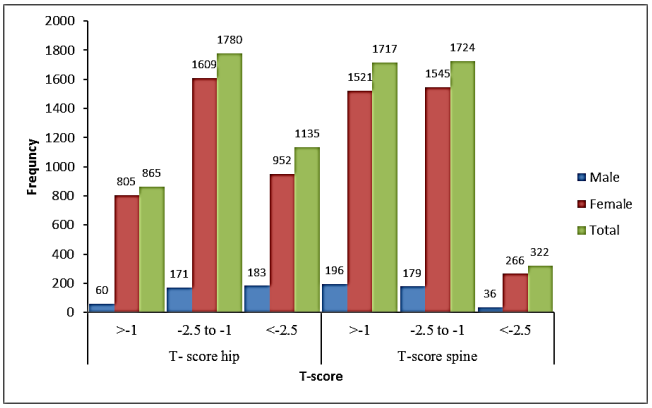

Figure 1. Frequency of T-score of hip and spine.

Table 2 shows the distribution of diagnostic measurements using WHO classification criteria. A BMI of more than 25 was shown to be a protective factor for major and minor discordance (Table 3). Major T-score discordance in men was greater than in women (11.11.0% vs. 3.95% *P*=0. 01). Indeed, major T-score discordance was associated with menopause (OR=1.5). In this study, major T-score discordance was directly correlated to age (r=0.908, *P*=0.005), but there was no statistically significant relationship between minor T-score discordance and age (*P*=0.07) (Table 4 and figure 2).

Table 2. Distribution of diagnostic discordances using WHO criteria

	Male n=414(10.95)	Female n=3366(89.05)	Total (N=3780)
Major T-score Discordance	46(11.11)	133(3.95)	179 (4.74)
Hip Osteoporosis Normal Lumbar	46(11.11)	128(3.80)	174(4.60)
Hip Normal Lumbar Osteoporosis	0	5(0.15)	5(0.14)
Minor T-score Discordance	224(54.11)	1485(44.12)	1709(45.21)
Hip Osteoporosis Lumbar Osteopenia	106(25.60)	588(17.47)	694(18.36)
Hip Osteopenia Lumbar Osteoporosis	5(1.21)	46(1.37)	51(1.35)
Hip Osteopenia Normal Lumbar	103(24.88)	726(21.57)	829(21.93)
Hip Normal Lumbar Osteopenia	10(2.42)	125(3.71)	135(3.57)
T-score Concordance	141(34.06)	1734(51.52)	1875(49.60)
Hip and Lumbar Osteoporosis	31(7.49)	235(6.98)	266(7.04)
Hip and Lumbar Osteopenia	63(15.22)	832(24.72)	895(23. 68)
Hip and Lumbar Normal	47(11.35)	667(19.82)	714(18.89)
Unknown	3(0.72)	14(0.41)	17(0.45)

Table 3. Prevalence of diagnostic discordances by BMI using WHO criteria in subjects

	BMI≤25 Total: 986	Prevalence (per 100)	BMI>25 Total: 2735	Prevalence (Per100)	Prevalence Ratio (CI 95%)
Major T-score Discordance	66	6.69	113	4.13	1.62 (1.21-2.27
Minor T-score Discordance	487	49.39	1200	43.87	1.12 (1.07-1.44)
T-score Concordance	43	4.36	1392	50.89	0.08 (0.05-0.09)

Table 4. Prevalence of diagnostic discordances by age group using WHO criteria

Age group	20-29	30-39	40-49	50-59	60-69	70-79	80≤
Major T-score Discordance	1.2	1.6	2.3	3.2	5.7	11.1	17
Minor T-score Discordance	44.4	57.4	56.2	54.9	45.6	35.2	30.8
T-score Concordance	53.7	41	41.5	41.7	48.7	55.4	52.1

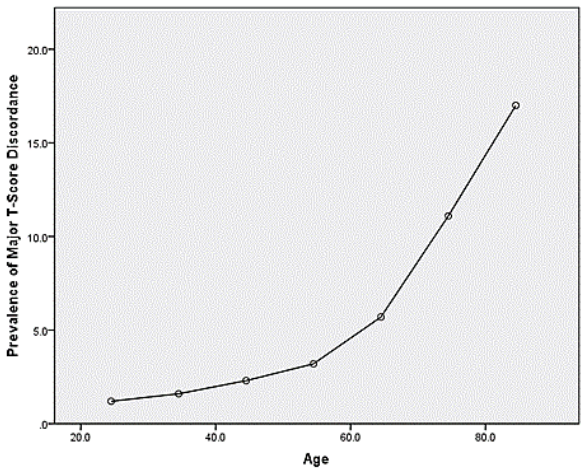

Figure 2. Association Major T-Score by age

In our study, the association between major T-Score discordances in the hip and spine was more prevalent. This is because rates of bone loss are significantly different between the anatomic regions in the same person. Another reason may be because of the different speeds and importance of bone loss in trabecular than cortical bone.

Discussion

Our study demonstrated that 1888 (49.95%) of the participants had a T-score discordance. But only 179 (4.74%) of them had major discordance. Our findings are almost in line with those of Woodson (16), Moayyeri (17), Maghraui (18), and Derakhshan *et al*. (19) (Table 5).

Table 5. Comparison of the results of the current study with other published studies

Studies	Major T-score Discordance	Minor T-score Discordance	T-score Concordance	ref
Woodson(n=5627)	247(4.3)	1927(35.0)	2762(49)	(16)
Moayyeri(n=4188)	115(2.7)	1631(38.9)	2442(58.3)	(17)
Maghraui(n=3015)	129(4.3)	1250(41.5)	1636(54.3)	(18)
Derakhshan(n=3039)	56(1.8)	1215(40%)	1768(58.2)	(19)
Our study	179 (4.74)	1709(45.21)	1875(49.60)	-

Numbers are presented as frequency (percentage in parenthesis)

The most important risk factors for major discordance were age (figure 1), menopausal duration, and BMI.

The high prevalence of T-Score discordance can make decisions about OP patients more difficult for practitioners. In conclusion, the high rate of T-score discordance between the hip and spine demonstrates a cut-off value defect in the correct definition of OP and Osteopenia, according to WHO (20). T-score discordance between the lumbar spine and total hip testing sites is a commonly observed phenomenon in densitometry. Discordance in the diagnosis of osteoporosis is defined when there are different categories of T-scores in the two skeletal sites of an individual patient (21). This phenomenon is divided into two subgroups: major and minor. Minor discordance happens when the different diagnostic classes are adjacent; i.e., the patient is diagnosed as osteoporotic in one site and osteopenic in the other site or osteopenic in one site and normal in the other site. If the diagnosis is osteoporosis in one site and the other site is in the normal range, the discordance falls into the major class. Actually, as the presence of discordance can affect the diagnosis and therapeutic plan in an individual person, it is highly recommended to measure BMD in several sites (16).

In summary, clinicians should be prepared for at least four out of ten patients tested by DXA to show either minor or major T-score discordance between the spine and hip. Disagreement on the T-score can be related to the patient's physiological and pathological factors for a variety of reasons, as well as the performance or analysis of DXA. There are also many technical reasons for discordance, including artifacts outside the body. Some reasons are physiological. Some reasons for spine higher BMD Include Arthritis, Ankylosing spondylitis, Aortic calcifications, Compression fractures, Chronic Kidney Disease, Calcium tablets, and Navel jewelry. Also, some causes of spine lower BMD include Estrogen deficiency, Glucocorticoids, Scoliosis (sometimes), and Laminectomy (22). Among the major factors involved in hip higher BMD are Exercise, Paget's disease, and Blastic lesions. Finally, the factors influencing Hip lower BMD will be included Spinal cord injury, Hyperparathyroidism, Regional osteoporosis, Lytic lesions, and Fibrous dysplasia. Clinicians should expect that at least half of patients tested by DXA will demonstrate T-score discordance between spine and total hip measurement sites. T-score discordance can occur for a variety of reasons related to physiologic and pathologic patient factors as well as the performance or analysis of DXA itself (23).

According to previous literature, T-score discordance could be due to physiologic, anatomic, pathophysiologic, artefactual, or technical. Physiologic discordance is associated with the skeletal natural adaptive reaction to normal external and internal factors and forces. Anatomic discordance occurs due to differences in the composition of bone envelopes tested. Pathophysiologic discordance is secondary to a disease, and artefactual discordance occurs when dense synthetic substances are found within the field of scanning. Technical discordance may occur due to the improper positioning of the patient by the operator (24). It should be noted that this survey is a cross-sectional study and has its limitations. Based on our conclusion, it is not possible to judge discordance conclusively in measuring bone density. One of its limitations is the cohort effect. The changes seen in the

presence of BMD, such as osteoporosis of the spine or hip, are not necessarily related to age but may be due to his lower BMD in childhood, which can be a cause of discordancy. Also, in this study, some factors affecting osteoporosis, such as physical activity, nutrition, and medications, have not been investigated, which may affect the results of this study (25). Reference bias is another limitation of this study. This study was performed in a university teaching hospital; the sample may not be representative of the community, so it cannot be generalized to the population (26). However, discordance is a real finding, and clinicians should be familiar with this issue and adopt specific strategies for these patients to investigate the cause or causes of the discordance. If discordance is not justified, further follow-up is not recommended.

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References

1. Clynes MA, Harvey NC, Curtis EM, Fuggle NR, Elaine M, Cooper C. Europe PMC Funders Group The Epidemiology of Osteoporosis. Br Med Bull 2020;133:105-17.
2. Cawston H, Maravic M, Fardellone P, Gauthier A. Epidemiological burden of postmenopausal osteoporosis in France from 2010 to 2020 : estimations from a disease model. Arch Osteoporos 2012;7:237-46.
3. Kumar KS, Bhaskar P. Osteoporosis-an emerging disease of the 21st century, Part 1: an overview. J Family Med Prim Care 2012;1:66-8.
4. A, Guerboub AA, Achemlal L, Mounach A, Nouijai A, Ghazi M, et al. Bone Mineral Density of the Spine and Femur in Healthy Moroccan WomenNo Title. J Clin Densitom 2006;9:454-60.
5. Cooley H, Jones G. A population-based study of fracture incidence in southern Tasmania: lifetime fracture risk and evidence for geographic variations within the same country. Osteoporos Int 2001;12:124-30.
6. Hasserius R, Karlsson MK, Nilsson BE, Redlund-Johnell I, Johnell O; European Vertebral Osteoporosis Study. Prevalent vertebral deformities predict increased mortality and increased fracture rate in both men and women: a 10-year population-based study of 598 individuals from the Swedish cohort in the European Vertebral Osteoporosis Study. Osteoporos Int 2003;14:61-8.
7. Kanis JA, Oden A, Johnell O, De Laet C, Jonsson B, Oglesby AK. The components of excess mortality after hip fracture. Bone 2003;32:464-73.
8. Women A, Trombetti A, Herrmann F, Hoffmeyer P, Schurch MA, Bonjour JP. Survival and potential years of life lost after hip fracture in men and age-matched women Osteoporos Int 2002; 13:731-7.
9. Pande I, Scott DL, O'Neill TW, Pritchard C, Woolf AD, Davis MJ. Quality of life, morbidity, and mortality after low trauma hip fracture in men. Ann Rheum Dis 2006;65:87-92.
10. Haentjens P, Johnell O, Kanis JA, Bouillon R, Cooper C, Lamraski G, et al. Evidence From Data Searches and Life-Table Analyses for Gender-Related Differences in Absolute Risk of Hip Fracture After Colles' or Spine Fracture: Colles' Fracture as an Early and Sensitive Marker of Skeletal Fragility in White Men. J bone Miner Res 2009;19:1933-44.
11. Meybodi HA, Heshmat R, Maasoumi Z, Soltani A, Hossein-Nezhad A, Keshtkar A, et al. Iranian osteoporosis research network: background, mission and its role in osteoporosis management. Iran J Public Health 2008;37:1-6.
12. WA Peck. Consensus development conference: diagnosis, prophylaxis, and treatment of osteoporosis. Am J Med 1993;94:646-50.
13. WHO. Assessment of Fracture Risk, its Application to Screening for Postmenopausal Osteoporosis. Assessment of Fracture Risk and Its Application to Screening for Postmenopausal Osteoporosis, 1994.
14. 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;5:3.
15. Gold DT. The nonskeletal consequences of osteoporotic fractures. Psychologic and social outcomes. Rheum Dis Clin North Am 2001;27:255-62.
16. Woodson G. Dual X-ray absorptiometry T-score concordance and discordance between the hip and spine measurement sites. J Clin Densitom 2000;3:319-24.
17. 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.
18. El Maghraoui A, Abayi DA, Ghozlani I, Mounach A, Nouijai A, Ghazi M, et al. Prevalence and risk factors of discordance in diagnosis of osteoporosis using spine and hip bone densitometry. Ann Rheum Dis 2007;66:271-2.
19. Derakhshan S, Shahsavari S. Discordance in diagnosis of osteoporosis using spine and femur bone densitometry: prevalence and related factors. Iran J Nucl Med

2012;20:14-9.

20. Faulkner KG, von Stetten E, Miller P. Discordance in patient classification using T-scores. J Clin Densitom 1999;2:343-50.
21. Aziziyeh R, Perlaza JG, Saleem N, Sadat-ali M, Mctavish RK, Duperrouzel C, et al. Scorecard and economic model Ac ce pt e d us cr. J Med Econ 2020;23:767-75.
22. Lamichhane AP. Osteoporosis-an update. JNMA J Nepal Med Assoc 2005;44:60-6.
23. Thambiah SC, Yeap SS, Chretien G, Martin F. Osteoporosis in South-East Asian Countries. Clin Biochem Rev 2020;41:29-40.
24. Siamak D, Sirous S. Discordance in diagnosis of osteoporosis using spine and femur bone densitometry: prevalence and related factors. Iran J Nucl Med 2012;20:14-9.
25. Yeap SS, Hew FL, Damodaran P, Chee W, Lee JK, Goh EML, et al. A summary of the Malaysian Clinical Guidance on the management of postmenopausal and male osteoporosis. Osteoporos Sarcopenia 2016;2:1-12.
26. Li-Yu J, Perez EC, Cañete A, Bonifacio L, Llamado LQ, Martinez R, et al. Osteoporosis Society of Philippines Foundation, Inc. (OSPFI); Philippine Orthopedic Association (POA) Clinical Practice Guidelines Task Force Committee on Osteoporosis. Consensus statements on osteoporosis diagnosis, prevention, and management in the Phil. Int J Rheum Dis 2011;14:223-38.