Discordance Between Hip and Spine Bone Mineral Density Measurement Using DXA: Prevalence and Risk Factors

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Background: Diagnostic discordance for osteoporosis is the presence of different categories of T-scores in 2 skeletal sites of an individual patient, falling into 2 different diagnostic categories identified by the World Health Organization classification system.

Objectives: To evaluate the prevalence and risk factors for T-score discordance between spine and total hip measurement sites.

Methods: Demographic data, anthropometric measurements, and risk factors for osteoporosis were derived from a database of 3479 patients referred to a community-based outpatient osteoporosis testing center. Dual-energy x-ray absorptiometry (DXA) was performed on L1-L4 lumbar spine and total hips for all cases. Minor discordance was defined as present when the difference between 2 sites was no more than 1 World Health Organization diagnostic class. Major discordance was present when 1 site is osteoporotic and the other is normal. Subjects with incomplete data were excluded.

Results: In 3479 participants (2871 women; mean age, 55.7 ± 11.9 years), concordance of T-scores, minor discordance, and major discordance were seen in 54, 42, and 4%, respectively. In multivariate logistic regression analysis, age, menopause, and obesity were identified as risk factors against T-score discordance.

Conclusion: Densitometrists and clinicians should expect that at least 4 of every 10 patients tested by DXA to 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.

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Bone mineral density (BMD) assessed by dual-energy x-ray absorptiometry (DXA) is used to diagnose osteoporosis, assess fracture risk (1), and monitor changes in BMD over time. DXA has many advantages: short scan times, quick setup of patients, low radiation dose, and good measurement precision. The World Health Organization (WHO) has proposed a set of operational criteria to define osteoporosis in postmenopausal white women (2). Bone measurements are expressed as T-scores, which are the difference between the patients measurements and a mean value for a young adult population and divided by the young adult standard deviation. The International Society for Clinical Densitometry has recommended that BMD should be measured for the purpose of diagnosing osteoporosis at 2 preferred skeletal sites, the hip and lumbar spine. A third site (33% or one-third of the radius of the nondominant forearm) should be investigated if technical problems arise at any of these 2 primary sites. The International Society for Clinical Densitometry recommended also that osteoporosis be diagnosed on the basis of the lowest T-score for BMD found at the spine, total hip, and femoral neck (3). Actually, 1 of the reasons for measuring BMD in several sites is the presence of discordance, which can affect the diagnosis and therapeutic plan in an individual person.

Discordance in diagnosis of osteoporosis is defined as the presence of different categories of T-scores (osteopo-

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rosis, osteopenia, and normal) in 2 skeletal sites of an individual patient (4). This phenomenon has been divided into 2 groups: major and minor (5). Minor discordance happens when the different diagnostic classes are adjacent, ie, patient is diagnosed as osteoporotic in 1 site and osteopenic in the other site, or, osteopenic in 1 site and normal in the other site. If the diagnosis is osteoporosis in 1 site and the other site is in the normal range, the discordance falls into the major class.

Various studies have analyzed the prevalence and impact of T-score discordance on the management of osteoporosis (5-10). However, most of these studies did not evaluate risk factors for this phenomenon. Thus, we aimed in this study to evaluate the presence and risk factors for T-score discordance in a large sample of patients.

METHODS

Patients

This was a retrospective review of DXA data collected from March 2003 to July 2007 from 1 center. Data were evaluated for all patients who had lumbar spine and hip scans performed in the same scanning session. Participants were excluded if BMD was affected by documented pathology or technical issues. A considerable proportion of these cases were healthy postmenopausal women consulting spontaneously or referred by clinicians for densitometric evaluations (11). A total of 3479 patients were identified with 608 men and 2871 women. The mean age was 54.9 (range, 20 to 92 years). Informed consent was obtained from all of the participants. The research protocol was approved by our institutional review board.

A standardized questionnaire was filled before densitometry for all participants. Demographic data (including age and sex) as well as other known or suspicious risk factors for osteoporosis (including menopause, age at menopause, age at menarche, history of osteoporotic fractures, drugs, and smoking) were collected. All participants had their standing height and weight measured. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared.

BMD Measurement

All the BMD measurements were done for diagnostic purposes and none of the participants were on treatment with bone active agents (hormone replacement therapy was not considered a bone active agent). BMD was determined by a Lunar Prodigy Vision DXA system (Lunar Corp., Madison, WI). The DXA scans were obtained by standard procedures supplied by the manufacturer for scanning and analysis. All BMD measurements were performed by 2 experienced technicians. Daily quality control was performed by measurement of a Lunar phantom. At the time of the study, phantom measurements showed stable results. The phantom precision expressed as the coefficient of variation (%) was 0.08. Moreover, reproducibility has been assessed recently in clinical practice and showed a smallest detectable difference of 0.04 g/cm^2 (spine) and 0.02 (hips) (12,13). Patient BMD was measured at the lumbar spine (anteroposterior projection at L1-L4) and the femurs (femoral neck, trochanter, ward, and total hip).

Using the Moroccan normative data for lumbar spine and hip (14), and the WHO diagnosis of osteoporosis (T-score $\leq$ 2.5) and osteopenia ($-1 \leq$ T-score $<$ 2.5), each patient was categorized as having 1 (only) of the following: concordance (osteoporosis, osteopenia, or normal BMD on both sites), minor discordance (osteoporotic in 1 site and osteopenic in the other site, or osteopenic in 1 site and normal in the other site), and major discordance (osteoporosis in 1 site and the other site is in the normal range).

Statistical Analysis

Independent sample t-test and χ^2 test were used first to compare presence of various risk factors in participants with and without T-score discordance. Potential risk factors were entered to a multivariate logistic regression analysis and the resulted odds ratios with 95% confidence intervals were reported. P values less than 0.05 were taken to indicate statistical significance. Statistical analyses were performed using SPSS 13.0.

RESULTS

Characteristics of the 3479 participants are summarized in Table 1. The main reasons of referral for BMD measurement were menopause in 50%, old age in 20%, glucocorticoid use in 7%, history of low energy fractures in 1.5%, and other reasons (such as metabolic disorders, rheumatoid arthritis, osteoporotic fracture family history,

Table 1 Characteristics of the Study Population

	Men (n = 608)	Women (n = 2871)
Age (yr)	51.1 (15.1)	55.7 (11.9)
Weight (kg)	72.6 (12.8)	70.8 (12.9)
Height (cm)	171.4 (6.9)	157.4 (6.2)
Body mass index (BMI) (kg/cm^2)	24.7 (4.0)	28.6 (5.0)
History of osteoporotic fracture	8 (2.4)	47 (1.2)
Corticosteroid use	41 (7.8)	127 (5.1)
Hormone replacement therapy		6 (0.2)
Menopause		1739 (57.7)
Total hip BMD (g/cm^2)	0.978 (0.15)	0.903 (0.14)
Lumbar spine BMD (g/cm^2)	1.071 (0.18)	0.976 (0.17)
Total hip T-score	−0.50 (1.21)	−0.91 (1.21)
Lumbar spine T-score	−1.02 (1.51)	−1.62 (1.45)

Numbers are presented as mean (standard deviation in parentheses) for numerical variables and frequency (percentage in parentheses) for categorical variables.

Table 2 Classification of T-scores According to the WHO Criteria in the Lumbar Spine and Total Hip

	Men (n = 608)				Women (n = 2871)				Total (n = 3479)			
	LS		TH		LS		TH		LS		TH	
	N	%	N	%	N	%	N	%	N	%	N	%
Osteoporosis ($T \leq -2.5$)	106	17.4	53	9	855	29.8	483	17	961	27.6	536	15
Osteopenia ($-2.5 < T \leq -1$)	227	37.3	238	39	1122	39.1	1341	47	1349	38.8	1579	45
Normal ($T > -1$)	275	45.2	317	52	894	31.1	1047	37	1169	33.6	1364	39

LS, lumbar spine; TH, total hip.

etc) in 4.5% of participants. In 17% of participants, no major risk factor was identified as the referral reason.

There were 536 participants diagnosed in osteoporotic range at the hip site and 961 participants at the lumbar spine. T-score classifications are presented in Table 2. Major discordance was observed in BMD results of 154 (4%) participants. Minor discordance was observed in 1449 (42%) participants and T-score categories of 2 measurement sites in another 1878 (54%) participants were concordant. Distribution and pattern of this variable for both sexes are reported in Table 3.

T-score discordance was equally observed in women and men (47% versus 42%, $P = 0.42$). The mean age of participants with discordance (56.7 years) was higher than the other group (53.3 years, $P < 0.001$). In 2871 female participants, the number of postmenopausal women with diagnostic discordances (750 of 1416) was significantly higher than premenopausal participants with discordance (183 of 583; $P < 0.0001$). In multivariate analysis (Table 4), participants aged >50 years and those with menopause and obesity (defined as BMI over 30) were more likely to show major T-score discordance.

DISCUSSION

In our cohort, T-scores at the lumbar spine and total hip were concordant in 54% of patients and discordant by at least 1 diagnostic class in 46%. Minor discordance was found to be common, occurring in 41% of patients. Major discordance was rare, having a prevalence of only 4%, which is in agreement with the results of similar studies (Table 5). Age, obesity, and menopause were the main risk factors of major discordance between spine and hip T-scores.

In both major and minor discordances, lower BMD for lumbar spine was more prevalent. This could be due to several reasons. A possible explanation lies in the variable proportions of cancellous and cortical bone at the different sites. Cancellous bone, which represents 20% of total bone mass, has an accelerated metabolism and therefore a more rapid and earlier loss than cortical bone (15). This could be an important explanation of discordances in our relatively young population with rapid turnover at the spine in the early postmenopausal period, accounting for the high rate of osteoporosis based on lumbar spine BMD. Moreover, most of the etiologies of the secondary osteoporosis (such as glucocorticoid excess, hyperthyroidism, malabsorption, liver disease, rheumatoid arthritis, and medications) first affect the spinal column (16). This will lead to higher prevalence of lumbar osteoporosis. Another explanation is that weight-bearing can cause rise in bone density especially in the hip and femur regions, which is a well-known cause of physiologic dissimilarity (17). This mechanism could be the reason for more major T-score discordances observed by increment of BMI in our study, as confirmed by the multivariate analysis.

Table 3 Distribution of Diagnostic Discordances Using WHO Criteria According to Gender

	Men (n = 608)	Women (n = 2871)	Total (n = 3479)
Major T-score discordance	19 (3)	135 (5)	154 (4)
Hip osteoporosis, normal lumbar	1	4	5
Hip normal, lumbar osteoporosis	18	131	149
Minor T-score discordance	234 (38)	1215 (42)	1449 (42)
Hip osteoporosis, lumbar osteopenia	5	40	45
Hip osteopenia, lumbar osteoporosis	67	497	564
Hip osteopenia, normal lumbar	33	130	163
Hip normal, lumbar osteopenia	129	548	677
T-score concordance	355 (58)	1523 (53)	1878 (54)
Hip and lumbar osteoporosis	21	228	249
Hip and lumbar osteopenia	93	535	628
Hip and lumbar normal	241	760	1001

Numbers are presented as frequency (percentage in parentheses).

Table 4 Results of Multivariate Logistic Regression Analysis for Risk Factors of Major and Minor Discordance Getting T-score Concordance at Lumbar and Hip Sites as the Reference

	Minor discordance	Major discordance
Gender (female)	0.83 (0.07 to 9.21)	1.01 (0.05 to 7.32)
Age group (>50 yr)	1.65 (1.42 to 1.91)*	3.98 (2.39 to 6.62)*
Corticosteroid use	0.85 (0.60 to 1.21)	0.62 (0.22 to 1.72)
Body mass index (>30 kg/cm^2)	1.08 (0.93 to 1.24)	1.55 (1.11 to 2.15)*
History of osteoporotic fracture	2.83 (1.41 to 5.68)*	2.76 (0.96 to 7.91)
Menopause	1.99 (1.62 to 2.44)*	6.47 (2.81 to 14.89)*

*Significant odds ratio. Numbers are presented as odds ratio (95% confidence intervals in parentheses).

Woodson described 5 different causes for occurrence of discordance between the spine and the hip sites (5). *Physiologic discordance* is related to the skeleton's natural adaptive reaction to normal external and internal factors and forces. Mechanical strain especially related to weight-bearing plays a key role in this kind of discordance. An example of this type of discordance is the difference observed between the dominant and nondominant total hip. Moreover, the spine and hips start out with different T-scores (the spine is said to reach peak at least 5 years before the hip), and finally, bone loss observed with age in an individual may be more rapid and important in trabecular than cortical bone is another explanation. *Pathophysiologic discordance* is seen secondary to a disease. Common examples include vertebral osteophytosis, vertebral endplate and facet sclerosis, ankylosing spondylitis syndesmophytes, osteochondrosis, and aortic calcification (18-22). This abnormal calcium deposition within the field of the DXA region of interest leads to a falsely elevated spine T-score. *Anatomic discordance* is owing to differences in the composition of bone envelopes tested. An example is the difference in T-scores found for the posteroanterior lumbar spine and the supine lateral lumbar spine in the same patient. *Artifactual discordance* occurs when dense synthetic substances are within the field of region of interest of the test (barium sulfate, metal from zipper, coin, clip, or other metallic object). Finally, *technical discordance* occurs because of device errors, technician variability, patients' movements, and variation due to other unpredictable sources. We demonstrated in a previous study that DXA in vivo reproducibility is twofold better in the hips than the spine, especially when measuring both hips (12).

The high prevalence of T-score discordance, as observed in this study and similar studies, could induce some problems for the physicians in decision-making regarding these patients (23). It could suggest inaccuracies in the normative data used to calculate T-scores. In general, it suggests some defects in the cutoff values for definition of osteoporosis and osteopenia proposed with the WHO. The international societies interested in osteoporosis management recommend using DXA to measure BMD in both the hip and the spine and classifying the patient based on the lowest T-score of these measurements. The inconsistencies in the diagnostic classification of osteoporosis between skeletal sites lend credence to the notion that BMD should be used as only 1 of the factors in making therapeutic decisions when evaluating patients with osteoporosis. An international team convened by the WHO is trying to develop a globally applicable measure of absolute fracture risk based on multiple risk factors including BMD. This could silence much of the controversy regarding choice of reference data for T-score calculation and usefulness of relatively arbitrary densitometric categorizations (24).

Our study, as every cross-sectional study, has a number of limitations. The subjects in our sample were either referred or came in spontaneously for osteoporosis evaluations and may differ in some ways from the general population such as socioeconomic and education levels, or the prevalence of some conditions associated with osteoporosis (ie, the prevalence of smoking and alcohol consumption, vitamin D or calcium deficiency, or long-term corticosteroid use). Thus, the possibility of referral bias is not excluded and we could not generalize the results to the Moroccan population. However, data extracted from a randomly chosen sample from the general population used to establish the Moroccan normative BMD curve retrieved the same proportions of concordance between spine and hip sites (13). Further studies with long follow-up designs are needed to evaluate the impact of existing discordance on the prognosis and fracture risk of the patients.

Table 5 Prevalence of Concordance and Major and Minor Discordance of T-scores at the Lumbar and Hip Sites in the Published Studies

	N	Concordance (%)	Minor discordance (%)	Major discordance (%)
Woodson (5)	5051	56	39	5
Moayyeri (10)	4188	58.3	38.9	2.7
Our study	3479	53.9	41.6	4.4

In summary, this study confirmed that up to 45% of patients evaluated for bone density in a DXA referral center may show diagnostic discordance. The densitometrists and clinicians should be prepared to expect that at least 4 of every 10 patients tested to demonstrate either minor or major 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 (25).

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This section comprises references that occur in the reference list but not in the body of the text. Please position each reference in the text or delete it. Any references not dealt with will be retained in this section: [20].

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