

Discriminative ability of dual-energy X-ray absorptiometry site selection in identifying patients with osteoporotic fractures

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Abstract

Dual-energy X-ray absorptiometry (DXA) is the gold standard method for measurement of bone mineral density (BMD). The aims of the current study are to compare the ability of BMD measurements to identify subjects with vertebral fractures (VF), when the lumbar spine (LS), hip or both sites are measured.

460 subjects aged 73 ± 5.2 years participated in the study. Thoraco-lumbar spine radiographs were obtained and analyzed for the presence of VF using the visual semi-quantitative assessment. BMD of the LS and the left femur were measured by DXA. Eighteen men (12%) and 56 women (20%) had at least one VF. 16% of scans at the LS were unreadable because of the presence of degenerative changes. In both genders, BMD of the hip showed better ability than LS BMD in detecting subjects with osteoporosis. BMD and *T*-score values at the hip, but not the LS, were lower in subjects with VF than those without ($p < 0.05$). Femoral neck BMD showed the highest OR for each S.D. decrease in BMD for identifying subjects with VF, and the best predictability for prevalent VF using ROC. Fracture risk prediction did not increase by adding the spine to the hip measurement. In conclusion, hip BMD was the only and best skeletal site needed to detect subjects with osteoporosis and showed the strongest relationship with prevalent vertebral fractures in elderly subjects.

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Introduction

Osteoporosis is the most common metabolic bone disorder in humans, and fractures are the hallmark of the disease. Studies showed that bone mineral density (BMD) is a powerful predictor of osteoporotic fractures [1]. Dual-energy X-ray absorptiometry (DXA) is the gold standard method for measurement of bone mineral density (BMD). In clinical practice, treatment decisions are based on BMD measurements obtained by DXA and on the use of the World Health Organization (WHO) classification for the diagnosis of osteoporosis [2]. The WHO criterion applies to

BMD of three skeletal sites, the hip, lumbar spine or forearm. The hip and spine are the two most commonly used skeletal sites. The International Osteoporosis Foundation (IOF) recommends measurements of the hip only [3], whereas the International Society for Bone Densitometry (ISCD) recommends the measurement of BMD at both spine and hip in all patients, and measurement of the forearm if the hip and/or spine cannot be measured or interpreted [4].

The rate of bone loss differs according to the age of the patient and to the skeletal site. In the perimenopausal period and in the early post-menopausal period, bone loss occur mainly at the spine reflecting the effect of estrogen deficiency on trabecular bone [5], thus by measuring the hip only, the diagnosis of osteoporosis may be missed in this group of patients. Conversely, in elderly subjects, structural changes such as

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vascular calcifications, scoliosis and degenerative arthritis in the posterior elements of the spine may falsely increase BMD at the spine and therefore limit its utility [3]. The effect of degenerative changes on BMD is less commonly a problem at the hip.

Vertebral fractures are a hallmark of osteoporosis and occur in elderly subjects, the subgroup that is most likely to have degenerative changes at the spine. BMD measurements are one among other clinical risk factors that are used to identify subjects at risk for osteoporotic fractures.

The objectives of the current study are:

- 1 To discriminate ability of spine as compared to hip BMD in identifying elderly subjects with osteoporosis and subjects with vertebral fractures.
- 2 To assess the additional effect of combining BMD measurements of spine and hip in identifying elderly subjects with osteoporosis and subjects with vertebral fractures.

Materials and methods

Subjects

460 home-dwelling ambulatory subjects, aged 73 ± 5.2 years, [65–85] participated in a population-based study aiming at assessing the prevalence of osteoporosis and vertebral fractures in the elderly Lebanese population [6].

Exclusion criteria included the following: any medical condition likely to affect bone metabolism such as the history of a major chronic disease, the intake of medications known to affect bone metabolism, history of steroid intake for more than 6 months, treatment with bisphosphonates, SERM, calcitonin or hormone replacement therapy for more than 1 year during the last 5 years. Also excluded were subjects with history of bed rest for more than 1 month within 6 months prior to the study, subjects with previous surgery on the spine or both hips and those with history of radiotherapy or chemotherapy.

Eleven subjects (2 men and 9 women) were excluded from the analyses because of suspicion of primary hyperparathyroidism, based on a serum calcium ≥ 10 mg/dl and PTH levels above the upper limit of normal (76 pg/ml). On the other hand, radiographs were not obtained in 17 subjects. Thus, data of 432 subjects (282 women and 150 men) were used in the analyses.

The study was approved by the Institutional Review Board of the American University of Beirut, and informed consent was obtained from all study participants.

Assessments

Clinical data

All subjects underwent physical examination including height and weight measurements. The subject's standing height, using a wall stadiometer, was recorded in centimeters to the nearest 0.1 cm. Weight was recorded in kilograms, to the nearest 0.5 kg, with the participants wearing light clothes without shoes and using a standard clinical balance. The body mass index (BMI kg/m^2) was calculated.

Vertebral fractures data

Lateral radiographs of the thoraco-lumbar spine were obtained in all subjects in lateral decubitus position. The X-ray beam was centered on T8 vertebra for the dorsal spine and on L3 vertebra for the lumbar spine. Radiographs were assessed from T4 to L5 levels for the presence of vertebral fractures by two radiologists: [SH ($n=213$) and NK ($n=219$)], using the visual semi-quantitative method described by Genant et al. [7]. Mild fractures were excluded and only moderate (25–40% height loss) and severe fractures ($\geq 40\%$ height loss) were reported and used in the analyses [8,9]. A random sub-sample of 30 X-ray films was analyzed simultaneously by the two radiologists to assess the inter-reader variability. In view of the small sample size and consequently the small number of fractures, the inter-reader agreement was calculated without excluding mild fractures. It was 80.6%, kappa coefficient was 0.63.

Bone mineral density

a—Measurements. Areal bone mineral density BMD (g/cm^2) of the antero-posterior lumbar spine (L1–L4) and the left femur were measured by dual-energy X-ray absorptiometry (DXA) using a Hologic 4500A device [$n=219$] and a Hologic 4500 W [$n=213$] (Hologic, Bedford, MA, USA) in the two study centers.

b—Cross-calibration of densitometers. Thirty subjects had BMD at all skeletal sites simultaneously measured in both centers. Linear regression analyses were performed to allow conversion from one device to another. The following equations were derived:

$$\begin{aligned} \text{Spine: BMD QDR 4500A} &= 0.004 + 1.02 * \text{BMDQDR 4500W} \quad (R^2=0.95) \\ \text{Total Hip: BMD QDR 4500A} &= 0.05 + 0.98 * \text{BMD QDR 4500W} \quad (R^2=0.97) \\ \text{Femoral neck: BMD QDR 4500A} &= 0.21 + 0.67 * \text{BMDQDR 4500W} \quad (R^2=0.94). \end{aligned}$$

c—Quality control of the densitometer. The mean \pm S.D. for precision, expressed as the coefficient of variation (CV%) for 83 serial duplicate scans performed in vivo in a period overlapping the study duration, were as follows: Lumbar spine = $0.90 \pm 0.79\%$, Total hip = $0.84 \pm 0.70\%$, Femoral neck = $1.35 \pm 1.14\%$ and Trochanter = $1.08 \pm 0.84\%$.

d—Analyses of the scans at the spine. The scans were reassessed independently by two ISCD certified physicians (AA, GEHF), in order to exclude any effect of degenerative changes on BMD measurements at the spine. Vertebral body was excluded in the presence of one of the following criteria [10]: 1—focal structural defect, 2—unusual discrepancy in *T*-score between two adjacent vertebrae, 3—lack of increase in BMC or bone area when proceeding caudally from L1 to L4. In case of inter-observer disagreement, the most conservative approach was adopted. The average value for the readable vertebrae was then calculated, and the values were converted to be as if all subjects were measured on the Hologic 4500 A densitometer using the above cross-calibration formulas. Individual *T*-scores were derived using the NHANES database for the hip and the Western database provided by the manufacturer for the spine. *T*-scores at the spine were derived as follows: (Average BMD of the readable vertebrae - Peak BMD of the readable vertebrae) / S.D. Scans with less than two readable vertebrae were not included in the analyses. Lebanese database was not used to derive *T*-scores because there is no validation for the use of local database and, both IOF and ISCD recommend the use of universal database [3,4].

Statistical analyses

The difference between genders in the proportion of subjects with vertebral fractures was assessed using the chi-square test. The differences in BMD and *T*-scores between subjects with and those without vertebral fractures were assessed using the independent *t*-test.

Subjects were classified as osteoporotic or non-osteoporotic according to the WHO criteria (*T*-score ≤ -2.5). The sensitivity, specificity, positive predictive value and negative predictive value, and the ROC for identifying subjects with vertebral fractures were calculated.

The risk of having vertebral fracture for one S.D. decrease in BMD before and after adjustment for age were calculated by building two logistic regression models. In both models, the dependent variable was the presence of vertebral fractures. In the first model, the independent variable was *T*-score and in the second model the independent variables were *T*-score and age.

All analyses were performed using SPSS version 10.0 (SPSS, Chicago, Illinois).

Results

Anthropometric and vertebral fracture data

The clinical characteristics of the study population are shown in Table 1. There was no difference in the mean age between males and females. Men were taller than women ($p < 0.001$).

Table 1
Characteristics of the study population

	All n=432	Women n=282	Men n=150	p-value*
Age (years)	73.6±5.1	73.4±5.2	73.9±4.9	NS
Weight (kg)	70.5±14.5	69.5±15	72.3±11.1	0.04
Height (cm)	154.8±8.8	150.6±6.4	163.1±7.0	<0.001
BMI (kg/cm ²)	29.5±6.0	30.7±6.5	27.2±4.0	<0.001
Lumbar spine BMD ^a	0.810±0.1	0.769±0.1	0.887±0.1	<0.001
Lumbar spine T-score	-2.2±1.2	-2.5±1.1	-1.8±1.3	<0.001
Total hip BMD	0.772±0.14	0.730±0.12	0.848±0.1	<0.001
Total hip T-score	-1.9±1.0	-2.0±1.0	-1.7±1.0	0.001
Femoral neck BMD	0.633±0.09	0.614±0.09	0.669±0.09	<0.001
Femoral neck T-score	-2.8±0.8	-2.8±0.8	-2.8±0.8	NS
Vertebral fractures yes/no	17.1%	20%	12%	0.06

Values are mean±S.D.

* p-values for difference between men and women.

^a n=251 women and n=135 men.

Women had lower body weight ($p=0.01$) but higher BMI than men ($p<0.001$). As anticipated, BMD of the lumbar spine, total hip and femoral neck were higher in men than women ($p<0.001$).

Eighteen men (12%) and 56 women (20%) had at least one moderate or severe vertebral fracture by radiography ($p=0.06$ for difference between genders). The average number of fractures in those with at least one fracture was 1.8 ± 1.4 (range 1–7) for women and 1.3 ± 0.6 (range 1–3) for men.

The mean±S.D. of 25 (OH) vitamin D were 10.9 ± 5.0 ng/ml in women and 12.1 ± 4.6 ng/ml in men. The mean serum calcium, phosphorus and alkaline phosphatase were normal in both genders.

Bone densitometry data

When scans of the spine were reassessed using the ISCD criteria detailed under Materials and methods, there was inter-reader agreement in 85% of cases. The scans were judged unreadable in 50 women (17%) and 24 men (15%). The lumbar spine was assessable from L1 to L4 in only 91 women (31%) and 57 men (36%). Three vertebrae were readable in 101 women (37%) and 56 men (35%), and only two vertebrae were readable in 99 women (34%) and 46 men (29%).

When unreadable vertebrae were excluded, BMD was 2.8% lower in women and 2.5% lower in men than when no vertebra

was excluded. Similarly, when unreadable vertebrae were excluded, T-score was 0.13 S.D. lower in women and 0.23 S.D. lower in men than when no vertebra was excluded ($p<0.001$ for the difference in T-score).

Osteoporosis data

In both genders, T-score was higher at the spine than at the hip ($p<0.001$). According to WHO classification, 199 women (70.5%) had osteoporosis at the hip (T-score ≤ -2.5 at the total hip and/or femoral neck) and 126 (44.6%) women had osteoporosis at the spine. Among the latter group, only 110 subjects had osteoporosis at spine and hip. Thus, 89 women who had osteoporosis at the hip would have been missed if BMD was only measured at the spine and 16 subjects with osteoporosis at the spine would have been missed if BMD was only measured at the hip. In men, 109 subjects (72.6%) had osteoporosis at the hip and 43 subjects (28.6%) had osteoporosis at the spine. Among them, 36 men had osteoporosis at both sites. Thus, 73 men with osteoporosis at the hip would have been missed if BMD was measured only at the spine and 7 men with osteoporosis at the spine would have been missed if BMD was measured only at the hip.

BMD and fracture risk

In both genders, there was no difference in mean lumbar spine BMD or lumbar spine T-score between subjects with and without vertebral fractures (Table 2). Conversely, mean BMD and T-score of the total hip and the femoral neck were lower in subjects who had vertebral fractures than those who did not (Table 2). The T-scores at the hip were 0.4–0.6 S.D. lower in subjects with compared to those without vertebral fractures.

The sensitivity, specificity, positive predictive values, negative predictive values, as well as the ROC of BMD measurements in predicting subjects with prevalent vertebral fractures are shown in Table 3. In the overall group and in both genders, the highest sensitivity in detecting subjects with prevalent vertebral fractures, using the T-score at a single site, was obtained with the femoral neck (Table 3). The ROC were higher at the total hip and the femoral neck than at the spine. Using the lowest T-score of the two skeletal sites (spine and hip), or the average of T-scores, did not improve the ability of DXA

Table 2
Bone mineral density (BMD) and T-scores in subjects with and without vertebral fractures

	Women (n=282)		p-value	Men (n=150)		p-value
	With fractures n=56	Without fractures n=226		With fractures n=18	Without fractures n=132	
Spine BMD	0.740±0.1	0.775±0.13	NS	0.835±0.1	0.893±0.14	NS
Spine T-score	-2.8±1.1	-2.45±1.15	NS	-2.3±1.5	-1.76±1.32	NS
Total hip BMD	0.673±0.21	0.744±0.12	<0.001	0.792±0.1	0.855±0.12	0.05
Total hip T-score	-2.5±1.0	-1.92±1.00	<0.001	-2.1±1.2	-1.66±0.98	0.06
Femoral neck BMD	0.570±0.08	0.624±0.08	<0.001	0.626±0.09	0.674±0.09	0.06
Femoral neck T-score	-3.2±0.8	-2.70±0.83	<0.001	-3.2±0.8	-2.76±0.86	0.1

Values are mean±S.D.

p-values are for difference between subjects with and those without vertebral fractures.

Table 3
Sensitivity (Sen), specificity (Spe), positive predictive value (PPV), negative predictive value (NPV) and area under the curve for identifying subjects at risk for vertebral fractures using one or two sites in women and men

Gender	Site	Sens	Spec	PPV	NPV	ROC	95% CI
Women	Spine	59	49	19	85	0.59	0.49–0.68
	Total hip	51	71	30	86	0.65	0.56–0.73
	Femoral neck	80	37	23	88	0.65	0.56–0.73
	TH and FN (average <i>T</i>)	64	56	26	86	0.65	0.57–0.74
	LS, TH and FN (average <i>T</i>)	59	50	20	85	0.63	0.53–0.73
	LS, TH and FN (lowest)	83	27	19	88	0.53	0.43–0.63
Men	Spine	46	68	16	91	0.60	0.43–0.76
	Total hip	38	79	20	90	0.64	0.50–0.79
	Femoral neck	83	31	14	93	0.67	0.53–0.81
	TH and FN (average <i>T</i>)	66	61	19	93	0.66	0.52–0.80
	LS, TH and FN (average <i>T</i>)	40	68	14	89	0.60	0.44–0.75
	LS, TH and FN (lowest)	86	25	13	93	0.57	0.42–0.72
Overall	Spine	56	56	18	87	0.60	0.52–0.68
	Total hip	48	74	27	87	0.65	0.58–0.72
	Femoral neck	81	35	20	90	0.65	0.58–0.73
	TH and FN (average <i>T</i>)	64	58	23	89	0.66	0.59–0.73
	LS, TH and FN (average <i>T</i>)	54	56	18	87	0.63	0.55–0.71
	LS, TH and FN (lowest)	84	26	17	90	0.54	0.46–0.62

measurements to discriminate between subjects with and without prevalent vertebral fractures (Table 3).

The OR of having vertebral fracture for each S.D. decrease in bone density, according to the skeletal site are shown in Table 4. In the overall study group, the age adjusted OR for having vertebral fractures/S.D. decrease in BMD was 1.3 at the spine, 1.7 at the total hip and 1.85 at the femoral neck (Table 4). The estimates at the spine, total hip and femoral neck were significantly predictive of the risk of fracture in the overall group. They were significantly predictive of vertebral fracture with measurements at the total hip and femoral neck but not the spine in women, but did not reach statistical significance at any site in men. In both genders, the highest gradient was for the femoral neck (Table 4).

Similar results were obtained when we repeated the analyses using L1–L4 BMD and *T*-score, without deleting vertebrae with degenerative changes (data not shown).

Discussion

In this study the hip was the only and best site to identify elderly subjects with the diagnosis of osteoporosis by BMD,

and showed a stronger relationship with vertebral fracture than the spine.

To our knowledge, none of the studies assessing the relationship between spine BMD and vertebral fractures systematically reviewed scans for the presence of degenerative changes. Degenerative changes have a considerable influence on spinal bone mass measurements in elderly, increasing it by 0.5–1 S.D. [11–13]. Masud et al. found osteophytes at the spine in 44% of women with mean age of 70 years [11]. O'Gradaigh et al. reported degenerative changes in 10% of subjects aged 30–79 years [12]. In the current study, 16% of scans of the spine were judged unreadable and all four lumbar vertebrae could be used in only one third of subjects because of the presence of degenerative changes. The mean BMD decreased by around ¼ of S.D. after exclusion of vertebrae with degenerative changes, which would emphasize the relationship with vertebral fractures if it existed. The exclusion of vertebrae with degenerative changes was based on the analyses of the antero-posterior DXA images without confirmation by review of the X-ray images, therefore some degenerative changes may have been missed by DXA, influencing BMD measurements. We have not confirmed the presence of degenerative changes by radiographs, because in practice, DXA scans are usually analyzed without the availability of radiographs for comparison.

The percentage of subjects with osteoporosis was high with a mean *T*-score of –2.2 at the spine and –2.8 at the femoral neck. This was concordant with findings from other epidemiological studies showing higher prevalence of osteoporosis and osteopenia in Middle Eastern population compared with western population [14]. The prevalence of osteoporosis by BMD differs according to the age and the site used. Therefore, no single BMD measurement site can detect all cases of osteoporosis by DXA. In young postmenopausal women, bone loss occurs more commonly at the spine [5,15], whereas in elderly subjects, degenerative changes at the spine limit its utility [11–13]. In the current study, despite deleting vertebrae with suspected degenerative changes on BMD scans, the likelihood of missing the diagnosis of osteoporosis was much higher if BMD was measured at the spine only, a finding in part explained by the older age group in the study.

Hip and vertebral fractures are the hallmark of osteoporosis and are common causes of disability and increased morbidity and mortality in the elderly. Low bone density is one important determinant of fractures. Three aspects of the relationship between BMD and vertebral fractures were assessed in the current study. In the first model, BMD values were compared

Table 4
OR of vertebral fractures per S.D. decrease in BMD, before and after adjustment for age

	Women (<i>n</i> =282)		Men (<i>n</i> =150)		Overall (<i>n</i> =432)	
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
	Unadjusted	Adjusted for age	Unadjusted for age	Adjusted for age	Unadjusted	Adjusted for age
Lumbar spine	1.30 [0.96; 1.7]	1.22 [0.91; 1.6]	1.39 [0.97; 2.1]	0.99 [0.89; 2.1]	1.36 [1.07–1.73]	1.32 [1.04–1.68]
Total hip	1.78 [1.3; 2.4]	1.61 [1.16; 2.2]	1.65 [0.97; 2.7]	1.59 [0.93; 2.7]	1.79 [1.37–2.33]	1.67 [1.27–2.19]
Femoral neck	2.0 [1.4; 2.9]	1.82 [1.24; 2.6]	1.98 [1.0; 3.9]	1.91 [0.96; 3.8]	2.02 [1.47–2.78]	1.85 [1.33–2.58]

There were 56 women and 18 men with vertebral fractures.
Database NHANES for hip and densitometer database for spine.

between those with and without vertebral fractures. BMD measurements in subjects with prevalent vertebral fracture were lower at the total hip and femoral neck but not at the spine than in fracture free subjects. Conversely, Cauley et al. showed that, in subjects older than 65 years, both hip and spine BMD were lower in subjects with a prevalent vertebral fracture compared with those without fractures [16]. The difference persisted after calculation of volumetric BMD at the spine and femoral neck. The difference between the two studies is probably due to the different methods used to define vertebral fractures. In the current study, visual semiquantitative assessment was used and only moderate or severe fractures were included, whereas Cauley et al. used the morphometric definition of vertebral fractures [16].

In the second model assessing the relationships between BMD and fracture, we calculated the sensitivity and specificity of BMD in detecting subjects with prevalent vertebral fractures when the WHO criteria were applied. Femoral neck BMD showed the highest sensitivity in detecting prevalent vertebral fractures. In the third model, the OR per 1 S.D. decrease in BMD were calculated. The highest OR per one S.D. decrease in BMD for identifying subjects with prevalent vertebral fractures was obtained at the femoral neck. Similar results were observed by some [16–18] but not all studies [1]. Cauley et al. also showed a relationship between prevalent vertebral fractures and BMD at the hip and the spine, but the relationship was stronger with hip BMD especially in women [16]. Schneider et al. showed that, in postmenopausal women, the discrimination between subjects with and without vertebral fractures using DXA derived *T*-score, was better with total hip compared to spine (ROC 0.80 versus 0.67) [17]. When we combined both sites by selecting the lowest value, the combination did not improve the sensitivity of the test, it lowered the positive predictive value and the ROC in both genders, and in the overall group. In an analytic design similar to the one used in the current study, the investigators assessed the risk of vertebral fracture in the placebo arm of a large multicenter trial and found that the ability of BMD measurements in elderly subjects mean age 69 years in detecting vertebral fractures was higher when *T*-score of the femoral neck was used than when *T*-score of the spine or when the lowest *T*-score of the two sites was used [18]. Conversely, in a large meta-analysis, all skeletal sites had similar predictive abilities for predicting fractures except for measurement at spine for vertebral fractures and measurement at hip for hip fractures [1]. In this meta-analysis, the ROC were not calculated. To our knowledge, none of the above studies assessed simultaneously all aspects of the relationship between BMD and vertebral fractures as assessed in the current study, and only one study assessed the predictive ability of combined BMD measures as opposed to measuring one site only [18].

Few studies assessed the relationship between BMD and fractures in men, but none to our knowledge implemented a similar analytical design comparing skeletal sites to predict the presence of osteoporosis or vertebral fractures. A study conducted in men aged 26–80 years showed a strong association between vertebral fractures and BMD at both

spine and hip, but similar to our findings, the femoral neck BMD was the best site for estimation of fracture risk [19]. Conversely, Schneider et al. showed that discrimination between subjects with and without vertebral fractures was better with spine than hip BMD (ROC 0.67 versus 0.62) [17]. The mean age of men in the latter study was 52.7 years, much younger than the male population of our study (mean age 74 years), a group less likely to have degenerative changes at the spine that may affect the accuracy of BMD measurements at this site. In our study, the OR per one S.D. decrease in men were similar to those found in women but their effect failed to reach statistical significance. This lack of significance is likely to be attributed to the relatively small sample size and therefore of fractures in men.

The study population is obese and women were more obese than men (mean BMI of 27.1 kg/cm² and 30.6 kg/cm² in men and women respectively). These findings were concomitant with the findings of previous studies in the Middle Eastern region [20–22]. A national Lebanese survey found that more than 50% of adult Lebanese are overweight and 17% obese [20].

This study has some limitations. The sample size in men was smaller than that in women, and therefore the number of vertebral fractures was small in men. However the estimates derived in men in the literature and in this study were not different from those obtained in women. The study was cross-sectional, however, the gradients were similar to the relative risk for incident vertebral fracture per one S.D. decrease in BMD obtained in a prospective study conducted on population aged 47–95 years [23]. The mean serum 25 (OH) vitamin D was low and osteomalacia may masquerade as osteoporosis. However, as we previously described, the biochemical hallmark of osteomalacia was present in 2 subjects only, and we believe that the clinical and laboratory profile of study subjects is consistent with osteoporosis and not osteomalacia [6]. The inter-observer agreement for identifying vertebral fractures by X-ray was not very high (kappa 0.63), However, the studies assessed the inter-reader variability for the semi-quantitative assessment of vertebral fractures were very limited. We were able to identify only two studies [24,25]. In these two studies the kappa ranged between 0.79 and 0.96.

In conclusion, lumbar spine BMD in the elderly could be analyzed in its totality in only one third of subjects. Hip BMD showed better ability for detecting subjects with osteoporosis and subjects with prevalent vertebral fractures than spine BMD in women and similar trend was observed in men. There was no advantage in combining the two sites to predict vertebral fractures. This conclusion pertain only to adults over age 65 and may not be applicable to younger adults in whom lumbar spine BMD is often lower in the spine than the femur.

The risk estimates for hip BMD to predict prevalent vertebral fractures in a population-based sample of elderly Lebanese were similar to those derived in Western populations.

In elderly subjects, hip is the best and only skeletal site needed to predict the presence of osteoporosis and vertebral

fractures. This has important economic implications on public health strategies to assess osteoporosis burden.

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