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A prospective evaluation of bone mineral density measurement in females who have fallen

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Abstract

Background: the National Service Framework for Older Persons recognises the relationship between falls and osteoporosis; however, the best method for the evaluation of bone mineral density measurement in fallers is unclear. Dual energy X-ray absorptiometry of lumbar spine and hip is the gold standard for bone mineral density measurement, but is time consuming and may not be readily available. A cheaper, more portable alternative is peripheral dual energy X-ray absorptiometry of the heel. This predicts overall fracture risk as effectively as dual X-ray at the spine and hip, although site specific measurements provide the best estimate of fracture risk at a particular location.
Aims: 1. To validate peripheral dual energy X-ray in fallers by comparing heel bone mineral density measurement with measurements obtained at the lumbar spine and hip. 2. To determine the prevalence of osteoporosis in an unselected cohort of fallers.
Methods: 118 consecutive females over 50 attending for investigation of falls had heel bone mineral density measurement measured using peripheral dual energy X-ray (PIXI, Lunar). A representative sample of 52 (44%) also attended for bone mineral density measurement at the hip and lumbar spine using Hologic QDR 4500. Bone mineral density (g/cm^2) measurements were compared with mean values for young adults and age-related normals giving T (number of standard deviation units above or below the mean for normal young adults) and Z (number of standard deviations above or below the age-related normal mean) scores.
Results: in the total group [$n = 118$ mean (SD) age 74 (11)] heel bone mineral density was 0.4 (0.1), T score −1.1 (1.6) and Z score −0.1 (1.5). The relationship between absolute bone mineral density measurements taken at heel, total hip and lumbar spine were compared and the correlation coefficients show a strong positive relationship between all measurements (all r values > 0.54, $P < 0.0001$) with a particularly strong relationship between hip and heel ($r = 0.74$). Those with two or more risk factors for falls were significantly more likely to have lower bone mineral density.
Discussion: this study has shown that peripheral dual energy X-ray is a reliable method of assessment, applicable to use within a Falls Unit. In addition, although the prevalence of osteoporosis is not increased in unselected fallers, those with two or more risk factors for falls are at increased risk of osteoporosis and limited resources may be more appropriately targeted toward this group.

Keywords: *older people, falls, fractures, osteoporosis*

Introduction

Falls are among the most common and serious problems facing older people, and are associated with considerable morbidity, mortality, reduced functioning and premature nursing home admission [1–5]. Each year approximately 35–40% of people over 65 years of age fall, with up to 5% of falls resulting in fracture [6].

Hip fracture is one of the most costly and debilitating outcomes resulting from a fall but occurs in only 1% of falls [7]. However, 90% of hip fractures occur because of a fall. In addition to hip fractures, studies have shown that the great majority of upper extremity fractures also occur as a result of a fall [8].

Fracture is determined by the propensity to fall and also the underlying bone fragility. In current practice it is recognised that osteoporosis and falls services are largely separated and that patients attending either service may not have risk factors for the other investigated [9]. In recognition of this, the integration of falls and osteoporosis services is a major component of the recently published National Service Framework (NSF) for Older Persons [10]. The NSF suggests that osteoporosis prevention and treatment be considered in all fallers who are at risk of fracture, though the most effective means of delivering an effective falls and osteoporosis risk factor assessment into a Falls Service is unclear. This is particularly important when the NSF requires that services aim for a single assessment process or a 'one stop Falls Service'.

The prevalence of osteoporosis increases with advancing age and like injurious falls is a disease of the elderly. It is therefore surprising to discover the lack of data examining the prevalence of osteoporosis in fallers, particularly now that we have effective treatments for osteoporosis, that are known to reduce fracture risk [11].

Osteoporosis is defined as a bone mineral density measurement (BMD) of more than 2.5 standard deviations below the mean value for young adults (T score <-2.5) [12]. There is a strong inverse relationship between BMD and fracture risk, with a 2–3 fold increase in fracture incidence for each standard deviation reduction in BMD [13]. Although one small study has shown increased risk of hip fracture in fallers with low BMD [14], it is unclear if osteoporosis is the reason why some fallers sustain a fracture. It is also uncertain if other risk factors can identify those fallers at increased risk of osteoporosis, which would allow targeted interventions. However, the EPIDOS study has suggested that low femoral neck BMD, slow walking speed, impaired tandem walking, and poor vision are all independent risk factors for hip fracture [15].

Dual energy X-ray absorptiometry (DXA) of the lumbar spine and hip is currently regarded as the gold standard for measurement of BMD [11]. Measurement at a particular site provides the greatest predictive value of fracture at that location [13]. As hip fracture is the fall related fracture associated with the greatest excess mortality and morbidity, hip BMD measurements are particularly important. However, DXA measurements of the lumbar spine and hip are time consuming and may not be readily available to patients undergoing falls assessment. An alternative approach is to use peripheral dual energy X-ray absorptiometry (pDXA) of the forearm or heel, which uses less expensive, more portable equipment. Peripheral measurements predict the overall risk of fractures as effectively as spine and hip BMD [13, 16], but may be less useful in the diagnosis of osteoporosis, where hip BMD is currently regarded as the gold standard [11, 17]. Nevertheless, whilst previous studies have shown that peripheral measurements of BMD correlate with those obtained at the hip and spine [18], the use of peripheral techniques has not been validated as a reliable alternative in fallers.

This prospective study set out to determine the prevalence of osteoporosis in an unselected cohort of fallers and to determine whether groups at increased risk of osteoporosis can be identified, and to validate the use of portable devices for BMD measurement in fallers by comparing pDXA to the gold standard of hip BMD.

Methods

Consecutive females over 50 years of age attending the Regional Falls and Syncope Service for investigation of falls during a 3 month period were recruited prospectively.

Subjects provided details of the total number of falls and fracture history. In cognitively impaired subjects the history of falls and fall frequency was corroborated by a relative or carer. All subjects were screened for risk factors for falls. A recurrent faller was defined as two or more falls in the preceding year.

A cumulative score was given for each individual (maximum score 4, minimum 0) with a point scored for each of the following risk factors as originally outlined by Tinetti *et al.* [19].

1. Postural hypotension: defined as a drop in systolic blood pressure >20 mmHg or to <90 mmHg on standing.
2. Use of any benzodiazepine or other sedative-hypnotic agent.
3. Use of ≥ 4 prescription medications.
4. Impairment of gait and/or balance.

Gait and balance was examined in the out-patient setting using a 'get up and go' test and classified as normal or abnormal by one assessor, who was blinded to the results of the bone density measurements [20, 21]. Details of risk factors for osteoporosis were also recorded and included age at menopause, medications that accelerate bone loss and excess alcohol consumption, together with their use of treatments for osteoporosis.

All patients underwent pDXA measurements at the heel, using a peripheral instantaneous x-ray imaging DXA system (PIXI, Lunar). To allow validation of pDXA measurements against the gold standard of DXA at axial sites, a representative sample of almost 50% of the subjects also attended for BMD measurements at the hip and spine using Hologic QDR 4500. Both sets of BMD measuring equipment had the usual quality assurance checks performed before use.

Individual BMD (g/cm^2) measurements were compared with mean values for young adults and age-related normal subjects to give T (number of standard deviation units above or below the mean for normal young adults) and Z (number of standard deviations above or below the age related normal mean) scores respectively [12]. A diagnosis of osteoporosis was made from the axial BMD measurements, when the T score at lumbar spine or total hip was -2.5 or less (WHO criteria) [13]. For the pDXA measurements, osteoporosis was defined as a heel BMD

Table 1. Demographics and bone mineral density measurements in 52 fallers who attended for both PIXI and DXA.

		Total group	Previous fractures	No previous fractures
N		52	27	25
Age mean (SD)		73 (12)	73 (11)	73 (13)
Falls mean (SD)		4.2 (4.5)	5 (5.2)	4.4 (3.7)
Fractures mean (SD)		1 (1.3)	1.9 (1.2)	0
Heel Mean (SD) (PIXI)	BMD	0.43 (0.12)	0.4 (0.1)	0.4 (0.1)
	T score	−0.8 (1.5)	−1 (1.5)	−0.7 (1.5)
	Z score	0.1 (1.3)	−0.1 (1.2)	0.3 (1.4)
LS Mean (SD) (DXA)	BMD	0.9 (0.3)	0.8 (1.2)	0.9 (0.2)
	T score	−1.6 (1.5)	−1.8 (1.4)	−1.3 (1.7)
	Z score	0.6 (1.7)	0.4 (1.5)	0.9 (2)
Total hip Mean (SD) (DXA)	BMD	1.0 (0.1)	0.8 (0.1)	1.3 (0.2)
	T score	−1.6 (1.2)	−1.9 (1.2)	−1.4 (1.2)
	Z score	0.3 (1.1)	0.04 (1)	0.5 (1.3)

T score of <−1.6, which is equivalent to the WHO criteria for osteoporosis of a T score of <−2.5 at the spine or hip [22].

The relationship between the measurements taken using the pDXA and those at the lumbar spine and neck of femur were examined in each individual. Data are presented as mean and standard deviation. Comparisons were drawn between groups using the student's *t*-test. Correlation analyses and logistic regressions were obtained using 'Instat'. A value of $P < 0.05$ was considered a statistically significant result. The study was approved by the Newcastle Joint Ethics Committee and all subjects gave written informed consent. In those with cognitive impairment assent was also obtained from carer or next of kin.

Results

Heel measurements of BMD were made in 118 consecutive, unselected female subjects over 50 years of age attending for investigation of falls. Fifty-two [44%] of subjects also attended for BMD at the hip and spine and the results are shown in Table 1. This group was representative of the group as a whole with no significant differences in age, number of risk factors and frequency of fracture history between those attending for DXA and those not.

Table 2. Correlation between DXA and PIXI measurements of bone mineral density in 52 fallers. Values shown are R values with (95% confidence intervals) and *P* values

	Lumbar spine	Total hip
Heel	R = 0.54 (0.32–0.71) $P < 0.0001$	R = 0.74 (0.59–0.84) $P < 0.0001$
Total hip	R = 0.71 (0.53–0.82) $P < 0.0001$	–

Comparing BMD measurement at heel, lumbar spine and total hip in fallers

The relationship between absolute BMD measurements taken at heel, total hip and lumbar spine were compared and the correlation coefficients shown in Table 2 There was a strong positive relationship between all measurements (Figures 1 and 2) most particularly between BMD absolute values at hip and heel.

Of this group of fallers ($n = 52$), 13/52 [25%] had osteoporosis (determined by T score <−2.5) at total hip and 18/52 [35%] at lumbar spine, whilst at the heel 16/52 [31%] had osteoporosis (determined by T score <−1.6).

Measurement of heel BMD using pDXA in 118 fallers

One hundred and eighteen fallers attended for pDXA mean (SD) age 74(11). This group had sustained a mean (SD) of 6 (11) falls and had a mean (SD) 1.2 (0.9) number of risk factors for falls. Of this total group 46 (39%) reported a fracture history occurring over 50 years of age whilst 72 (61%) had no previous fracture history. Mean (SD) number of risk factors for falls in this total group was 1.2 (0.9) (maximum 4, minimum 0). Twenty-five were single fallers (21%) whilst 93 were recurrent fallers. Of the unselected group, BMD measurements are shown in Table 3. Of the total group of unselected fallers 46/118 [39%] had osteoporosis (determined by T score <−1.6). There were no significant differences in BMD, number of risk factors or number of fractures sustained between those with single compared to recurrent falls.

Those with 2–4 risk factor for falls were significantly older ($P = 0.0003$) and had significantly lower absolute BMD values ($P = 0.0009$), T scores (0.0005) and Z scores (0.0154) compared to those with 0–1 risk factor (Table 3).

There was no significant difference in BMD, fall frequency or risk factors for falls between those fallers who had sustained a fracture compared to those with no fracture history.

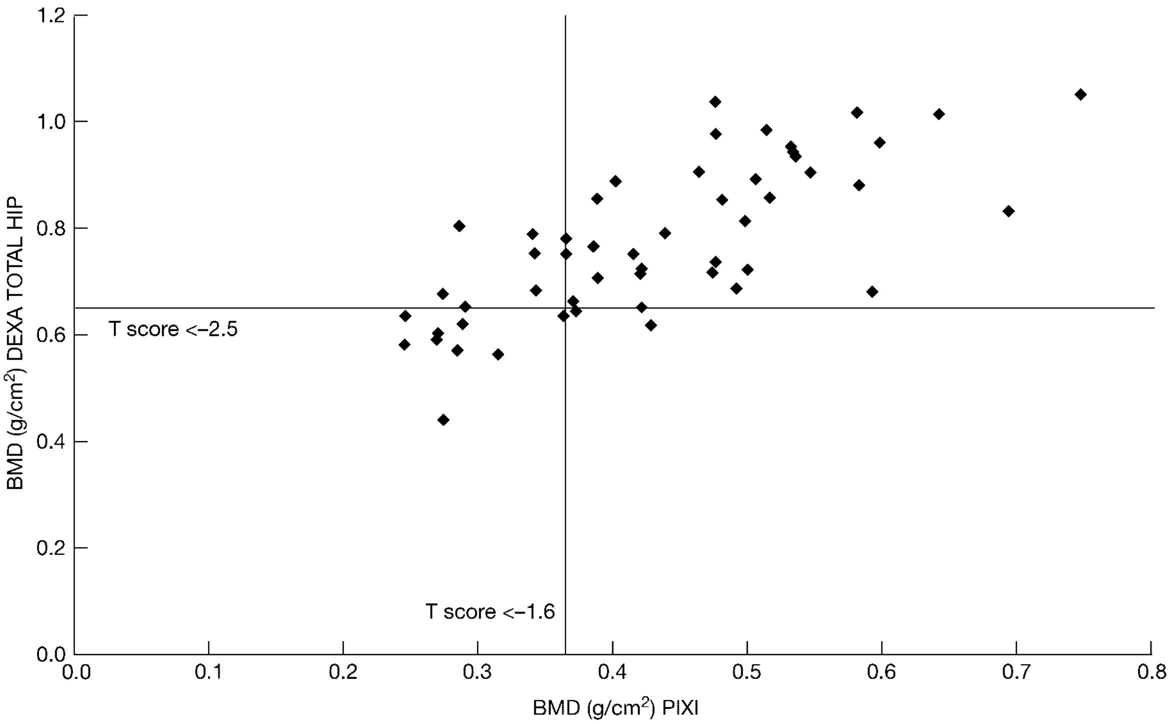

Figure 1. Correlation between absolute values of bone mineral density (g/cm^2) measured by PIXI and DXA at the hip. The absolute values that are associated with osteoporosis are shown i.e. T score < −1.6 for the PIXI and < −2.5 for DXA.

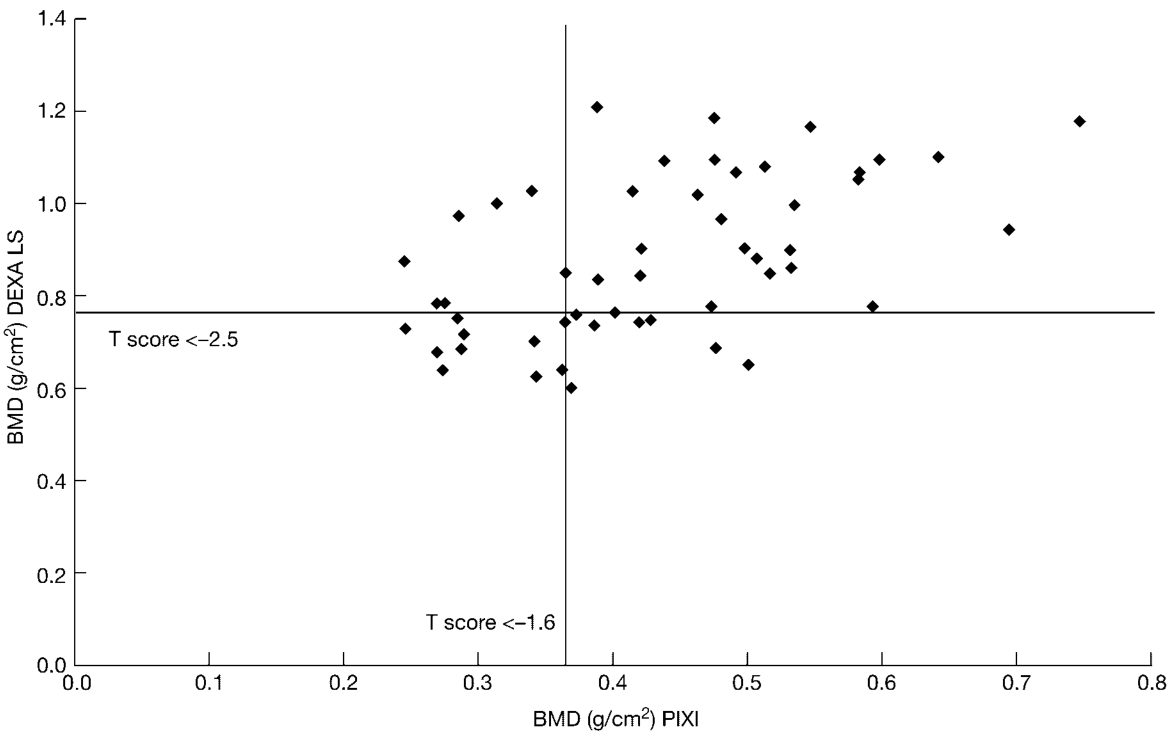

Figure 2. Correlation between absolute values of bone mineral density (g/cm^2) measured by PIXI and DXA at the lumbar spine. The absolute values that are associated with osteoporosis are shown i.e. T score < −1.6 for the PIXI and < −2.5 for DXA.

Table 3. Heel bone mineral density measured using PIXI in an unselected cohort of female fallers all values are expressed as mean (SD). Statistically significant results are shown $*P = 0.0003$; $**P = 0.0009$; $***P = 0.0005$; $****P = 0.0154$

		Number of risk factors for falls		Number of falls	
	Total	0–1	2–4	1 fall	Recurrent faller
N	118	73	45	25	93
Age	74 (11)	71 (11)*	78 (10)*	72 (10)	74 (11)
BMD g/cm^2	0.412 (0.126)	0.441 (0.122)**	0.365 (0.118)**	0.415 (0.113)	0.411 (0.129)
T score	−1.11 (1.57)	−0.75 (1.54)***	−1.69 (1.47)***	−1.12 (1.41)	−1.1 (1.62)
Z score	−0.1 (1.45)	0.11 (1.40)****	−0.40 (1.48)****	−0.2 (1.20)	−0.1 (1.51)
Risk factors mean (SD)		–	–	1 (1.1)	1.2 (0.9)
Fracture number mean (SD)		0 (1)	1 (1)	1 (1)	1 (1)
Falls mean number (SD)	6.0 (11)	5.8 (12)	6.3 (8.3)	–	7.4 (12)

Discussion .

Falls and osteoporosis are major chronic diseases common in older people. The present study has examined a consecutive cohort of female fallers and suggests that the prevalence of osteoporosis is not increased in fallers and that routine empirical use of osteoporosis treatment such as bisphosphonates, is therefore currently inappropriate. However fallers with two or more risk factors for falls are more likely to have osteoporosis than those with 0–1 risk factors and it may be appropriate for osteoporosis treatment to be targeted at those with increased risk factors for falls. However, osteoporosis is not a universal finding in those with two or more risk factors and we would recommend that ideally all subjects attending a Falls Service should have BMD measured. This study has shown that peripheral bone density measurement is a reliable assessment method, applicable to use within a Falls Unit.

It could be argued that the patients seen in our unit, which is based in a teaching hospital, are not representative of fallers seen in units generally. However, the patients in this study are predominantly (> 70%) referred directly from local general practices, which may limit any potential referral bias. Despite this we appreciate that confirmation of our results, possibly in a general hospital population, would be of value. It is important that further larger prevalence studies are now carried out in order to determine whether specific individual risk factors for falls or the character of the fall are associated with an increased risk of osteoporosis and fractures. Our study has also shown that measurement of BMD at the heel is strongly correlated with BMD at the hip. This is particularly relevant when considering that BMD at a particular site is predictive of fracture at that site. Being able to predict fracture risk at the hip using a peripheral method of assessment is vital when considering the high mortality and morbidity associated with hip fracture.

Our results suggest that peripheral BMD measurement is a reliable method for the identification of osteoporosis prevalence and assessment of fracture risk, even in those with no previous history of fracture. Further studies are required to determine whether treatment of osteoporosis with agents such as bisphosphonates in fallers (a group recognised at increased risk of fracture) does in fact reduce fracture rates. In addition it is also critical that work is directed towards determining whether giving bone-strengthening medication to fallers with increased risk of fracture but no, or borderline, osteoporosis may also prevent fractures.

Key points

- Female fallers are no more likely than age and sex matched controls to have osteoporosis.
- Those with ≥ 2 risk factors for falls are more likely to have osteoporosis.
- Heel bone mineral density measurement correlates well with lumbar spine and particularly hipbone mineral density.

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