Fracture risk among older men: osteopenia and osteoporosis defined using cut-points derived from female versus male reference data

Running title: Fracture risk, osteopenia and osteoporosis in older men

Julie A Pasco[1,2,3] BSc(Hons), DipEd, MEpi, PhD

Stephen E Lane[1,4] BSc(Hons), PhD

Sharon L. Brennan[1,2,5] BA(Hons), PhD, GCALL

Elizabeth N Timney[1] BHSc, BSc(Hons)

Gosia Bucki-Smith[1] BSc, MNutrDiet

Amelia G Dobbins[1] BHSc/Comm

Geoffrey C Nicholson[2,6] MBBS, FRACP, FRCP, PhD

Mark A Kotowicz[1,2,3] MBBS(Hons), FRACP

Affiliations: [1]School of Medicine, Deakin University, Geelong, Australia; [2]NorthWest Academic Centre, Department of Medicine, The University of Melbourne, St Albans, Australia; [3]Department of Medicine, Barwon Health, Geelong, Australia; [4]Biostatistics Unit, Barwon Health, Geelong, Australia; [5]Australian Institute for Musculo-Skeletal Science, The University of Melbourne, St Albans, Australia; [6]Rural Clinical School, School of Medicine, The University of Queensland, Toowoomba, Australia.

Corresponding author: Prof Julie A. Pasco, Epidemiology Unit for Musculoskeletal and Metabolic Disorders, School of Medicine, Deakin University, PO Box 281, Geelong 3220, Australia.
(Tel: +61 3 42153331, Fax: +61 3 42153491, e-mail: juliep@barwonhealth.org.au)

Reprint requests: As above

Word count: Abstract 250; Text 2417 Tables: 2 Figures: 1

ABSTRACT

Purpose: To describe fracture risk associated with osteopenia and osteoporosis in older men, defined by areal bone mineral density (BMD) and using cut-points derived from male and female reference data.

Methods: As part of the Geelong Osteoporosis Study, we followed 619 men aged 60-93yr after BMD assessments (performed 2001-6) until 2010, fracture, death or emigration. Post-baseline fractures were radiologically-confirmed and proportions of fractures in each BMD category age-standardised to national profiles.

Results: Based on World Health Organization criteria, and using male reference data, 207 men had normal-BMD at the femoral neck, 357 were osteopenic and 55 osteoporotic. Using female reference data, corresponding numbers were 361, 227 and 31. During the study 130 men died, 15 emigrated, 63 sustained at least one fracture. Using male reference data, most (86.5%) of the fractures occurred in men without osteoporosis on BMD criteria (18.4% normal-BMD, 68.1% osteopenia). The pattern differed when female reference data were used; while most fractures arose from men without osteoporosis (88.2%), the burden shifted from those with osteopenia (34.8%) to those with normal BMD (53.4%).

Conclusions: Decreasing BMD categories defined increasing risk of fracture. Although men with osteoporotic BMD were at greatest risk, they made a relatively small contribution to the total burden of fractures. Using male reference data, two-thirds of the fractures arose from men with osteopenia. However, using female reference data, approximately half of the fractures arose from those with normal-BMD. Using female reference data to define osteoporosis in men does not appear to be the optimal approach.

Keywords: DXA, epidemiology, fracture risk assessment, osteoporosis, general population studies

MINI ABSTRACT

We explored the effect of using male and female reference data in a male sample to categorise areal bone mineral density (BMD). Using male reference data, a large proportion of fractures arose from osteopenia, whereas using female reference data shifted the fracture burden into normal BMD.

INTRODUCTION

In chronic diseases the outcomes arise from the large population at moderate risk with the high risk population contributing less to the population burden. Collectively, musculoskeletal conditions, including osteoarthritis, rheumatoid arthritis, osteoporosis, fractures and others, rank fourth of the non-communicable diseases in terms of death and disability globally [1]. Earlier studies in Australia [2] and the USA [3] reported that the burden of fractures in older women arises from those with osteopenia. In Australia, osteoporosis is under-diagnosed and under-treated in women, even among those who have sustained fragility fracture [4, 5] and the situation is even worse for men [6]. This may, in part, be related to the lower prevalence of osteoporosis [7] and incident fracture in men [8]. Osteoporosis in both sexes has low salience among treating doctors [9] and the broader community [10]. Morbidity associated with fracture in men is considerable [11] and post-fracture morbidity and mortality are greater for men than women [12, 13].

The prevalence of osteopenia at the spine or femoral neck among Australian women aged 60 years and over is 48% (compared to 34% with osteoporosis) [7]. Although fracture incidence relative to bone mineral density (BMD) categories has been well studied in women [2, 3], there are few comparable data available for men. Using T-scores derived from a young normal male reference population to define osteopenia and osteoporosis in men at the spine or femoral neck, prevalence data for older Australian men are 57% and 9%, respectively [7]. The Committee of Scientific Advisors of the International Osteoporosis Foundation recently suggested that the young normal female reference range and standard deviation at the femoral neck be used to define BMD categories in men [14]. The adoption of uniform thresholds was suggested to avoid disparities in reference data

and differences in standard deviation of measurement, which contribute to inconsistencies in the literature regarding the relationship between BMD deficits and the risk for fracture. Given that the prevalence of osteoporosis in men is lower than in women and the fracture rates are lower, we sought to determine whether the burden of fractures in men also arises from those without osteoporosis using both male-derived and female-derived reference populations.

METHODS

Study sample and design

As part of the Geelong Osteoporosis Study, an age-stratified sample of men was selected at random from electoral rolls for the Barwon Statistical Division in south-eastern Australia; there was 67% participation [15]. The sampling frame used for recruitment was the Commonwealth electoral roll, because it contains a comprehensive register of all residents aged 18 years and over. In 2006, the Barwon Statistical Division had a population of 259,000 (24,517 men aged 60 years or more, ABS Catalogue No. 2001.0) with sufficient sociodemographic diversity for it to be representative of Australia [15, 16].

Only the older men, comprising 619 participants aged 60 years or more (median age 74.3 years; interquartile range, IQR, 67.4-81.5), were included in this analysis. Baseline BMD was measured at recruitment. As a continuous variable, BMD approximates a normal distribution and is commonly grouped into categories of normal BMD, osteopenia and osteoporosis on the basis of T-scores and nominal thresholds recommended by an expert panel of the World Health Organisation [17]. We adopted the practice of identifying osteopenia as the category of BMD defined by T-scores between -1.0 and -2.5 and

osteoporosis as T-score < -2.5.

Participants were followed from recruitment until the earliest of four possible events: an incident low trauma fracture, death, date of emigration from the study region, or end of follow-up (31 December 2010). All participants provided written, informed consent. The study was approved by the Barwon Health Human Research Ethics Committee.

Bone mineral density

Areal BMD measurements were performed at recruitment during the period 2001-2006 by dual energy x-ray absorptiometry, initially using a Lunar DPX-L densitometer (Lunar Corporation, Madison, WI, USA) for the first 215 participants, and subsequently using a GE-Lunar Prodigy (GE Lunar, Madison, WI, USA) for 405 participants, when the DPX-L was replaced. Cross calibration of the two scanners using 40 subjects aged 21-82 years yielded no significant differences in femoral neck BMD [18]. Long-term stability of the machines was monitored by scanning a phantom three times a week. BMD was measured at the femoral neck. Cut-off BMD values were calculated using Australian reference ranges for men [18] and women [19] corresponding to osteopenia (1.0-2.5 SD below the young reference mean) and osteoporosis (>2.5 SD below the young reference mean).

Fracture

Incident fractures that occurred after baseline were identified using a computerised keyword search of all radiological reports from the four medical imaging centres serving the region. This method of ascertaining fractures had been validated using hip fractures prior to the commencement of the study [20] and extrapolated to all fracture sites. Hip

fracture rates based on hospital discharge data (ICD-9 codes 820.0-820.9) were compared with rates obtained from radiology reports from all medical imaging services in the region. Age-specific hip fracture incidence from radiological reports was within the 95% confidence intervals for hospital discharge rates, with the number of cases from radiology reports exceeding those identified from hospital discharge data. Men who sustained fractures on more than one occasion were included once only, with details of their initial fracture event during the ascertainment period used in the analysis. Fractures of the skull, finger, toe, face, patella and clavicle were excluded, as were pathological fractures and fractures resulting from motor vehicle accidents, falls from ladders and striking people/objects. The 'time to fracture' represents the time interval between baseline assessment at recruitment and the fracture event, identified as the date of initial radiologic diagnosis.

Self-reported prior fractures were documented by questionnaire. Fractures were recognised as low trauma adult fractures if they occurred on or beyond the age 50 years and included spontaneous fractures, fractures resulting from strenuous activity, fractures after falls from standing height or less, "other and unspecified" falls or "cause unknown". A Lunar Prodigy densitometer was used to perform lateral vertebral morphometry (Lunar Prodigy, T10-12 and L1-4) for all participants at enrolment. Moderate and severe wedge, biconcave or compression deformities (>25% reduction in any vertebral height) were classified as morphometric vertebral fractures (MVFs) and these were also included as prior fractures.

Statistical analysis

The proportions of men with BMD in the normal, osteopenic and osteoporotic categories using both male and female cut-off points, and the proportion of fractures arising from each of these categories, were standardized to the Australian population statistics (ABS 2006; Catalogue No. 2001.0). Absolute 5-year fracture risks were similarly standardized and expressed as percentages (numbers of fracture cases over a 5-year period/100 persons at risk), with 95% confidence intervals (CI). We used Cox proportional hazards regression to estimate hazards ratio (HR) and 95% CI, predicting 'time to fracture' and controlling for age and prevalent fracture. Age was centred around the median to minimise collinearity effects. Interaction terms were tested in the models to check for effect modification. Statistical analyses were performed using R version 2.15.0 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Subject characteristics

Baseline measurements of femoral neck BMD and using male reference data, 207 men were identified with normal BMD, 357 with osteopenia and 55 with osteoporosis. Using female reference data identified 361 men with normal BMD, 227 with osteopenia and 31 with osteoporosis. During the study period, 63 men sustained at least one fracture (29 spine, 11 rib, 8 hip, 3 forearm, 3 femur, 3 Colles', 2 pelvis, 2 humerus, 2 carpal/metacarpal, 2 tarsal/metatarsal, 1 ankle and 1 tibia/fibula). During follow-up, 130 men died without fracture, 15 emigrated and 407 remained fracture-free. The median follow-up period was 6.4 years (interquartile range, IQR, 4.9 - 7.2), generating 3,590 person-years of follow-up. Table 1 lists the characteristics of the men, overall and

according to BMD status. The proportion of men with incident fracture increased with decreasing BMD. A similar pattern was observed for prevalent low trauma adult fracture.

Age-standardised data

Using male reference data, 36.6% had normal BMD, 56.3% had osteopenia and 7.1% had osteoporosis at baseline. Most (86.5%) of the fractures occurred in men without osteoporosis (18.4% in men with normal BMD, 68.1% in men with osteopenia) whereas 13.5% of the fractures occurred in men with osteoporosis (Figure 1).

Using female reference data, 62.4% had normal BMD, 33.4% had osteopenia and 4.2% had osteoporosis at baseline. Most (88.2%) of the fractures occurred in men without osteoporosis (53.4% in men with normal BMD, 34.8% in men with osteopenia) whereas 11.8% of the fractures occurred in men with osteoporosis (Figure 1).

Relative risk for fracture

Table 2 shows the relative risks for fracture according to BMD status defined using male and female reference data (normal BMD is the reference category). BMD categories in models 1 and 2 are defined using male and female reference data, respectively. Models 1 and 2 include prevalent low trauma adult fracture and age (centred about the median); model 1 also includes interaction terms between age and BMD. Using male reference data (model 1), the categories of decreasing BMD defined increasing risk of fracture and advancing age amplified this risk. Compared to men of median age (74 years) with normal BMD, those with osteoporosis were at greater risk for fracture (age-adjusted HR = 4.64, 95%CI 1.59, 13.51). The difference in risk between those with normal BMD and

osteopenia, and those with osteopenia and osteoporosis were not significant (age-adjusted HR = 2.02, 95%CI 0.93, 4.39 and HR = 2.29, 95%CI 0.97, 5.43, respectively).

Using female reference data (model 2), the interaction term between age and BMD was not significant. By changing from male to female reference data, the risk of fracture for men with osteoporosis was greater than for those with normal BMD (age-adjusted HR = 4.54, 95%CI 2.18, 9.45) and they were at greater risk compared to those with osteopenia (age-adjusted HR = 4.83, 95%CI 2.28, 10.22).

Models 3 and 4 include BMD standard deviations below the male and female reference means, respectively [18, 19]. Both models demonstrate independent contributions of increasing age, prevalent fracture and decreasing BMD contributing to fracture risk, with the gradient of risk similar when male and female reference data are used to express BMD in terms of standard deviations.

Absolute fracture risk

Age-standardised 5-year fracture risk in men for each category of BMD using male reference data is 17.04% (95%CI 5.74, 29.05) for men with osteoporosis, 6.90% (95%CI 3.97, 9.83) for those with osteopenia and 3.05% (95%CI 1.02, 5.08) for those with normal BMD. Using female reference data, comparable figures are 24.41% (95%CI 8.76, 40.07), 7.35% (95%CI 3.42, 11.28) and 4.07% (95%CI 2.09, 6.05). The inverse relationship between BMD and fracture risk is shown in Figure 1.

DISCUSSION

We report, as described by others, that fracture risk increases with advancing age, decreasing BMD and prior fracture [3]. Irrespective of cut-points used, men with osteoporosis have the greatest risk for fracture. Using male reference data, they represent 7.1% of men in the population and contribute only 13.5% of fractures, whereas, using female reference data, they represent 4.2% of the population yet contribute 11.8% of fractures. In both analyses, the majority of fractures arose from men without osteoporosis. However, using the male reference data, two-thirds of the fractures arose from men with osteopenia and who represent approximately half of the population at risk. In contrast, as a consequence of shifting the cut-points to lower values of BMD using female reference data, only one-third of the fractures arose from men with osteopenia and who represent approximately one-third of the population at risk. Furthermore, the proportion of fractures arising from those defined as having normal BMD increases from 18.4% to 53.4%.

As in our female cohort [2], the burden of fractures thus occurs in the population at moderate risk defined by BMD using male reference data, with individuals at high risk contributing a smaller proportion. This pattern is consistent with that observed in other chronic illnesses, as the Gaussian distribution of risk factors places the majority of the population at moderate risk. However, changing the reference population from male to female, distorts this pattern, shifting the population burden of fractures towards the upper part of the Gaussian distribution of BMD.

In our similar, population-based female cohort study, 73.1% of postmenopausal women with radiologically-confirmed fractures did not have osteoporosis on BMD criteria (T-score >-2.5) [2]. The bulk of fractures (56.5%) arose from those with osteopenia and

16.6% from those with normal BMD. That study involved 616 postmenopausal women, the follow-up phase spanned a median of 5.6 years, and BMD was measured at the proximal femur using DXA. The pattern was similar to an earlier report from a larger study of 149,524 postmenopausal US women who were followed for a shorter period of one year [3]. In that study, women on anti-fracture treatment were excluded, BMD was measured at the finger, heel or forearm using peripheral devices and incident fractures were self-reported. Despite these differences, the bulk of fractures came from those without osteoporosis (52% were osteopenic and 30% had normal BMD). However, had BMD categories been defined using male reference data, this pattern would likely show that the burden of fractures was shifted towards osteoporosis. A possible solution would be to define cut-points for osteoporosis in terms of absolute fracture risk irrespective of sex.

The strengths of our study are that it is a population-based prospective study in men and that BMD was measured at the proximal femur, as used in clinical practice and recommended by the Committee of Scientific Advisors of the International Osteoporosis Foundation [14]. Our male and female proximal femur reference ranges are similar to those reported by NHANES III [18, 21]. However, we also acknowledge the following limitations. We cannot exclude the possibility that a differential male-female 'healthy participant effect' might have biased our results. The risk estimates for fracture are based on baseline BMD and do not take into account changes in BMD that may have led to a change in classification over the period of observation. The number of men who sustained incident fractures during follow-up was small and replication of this study in a larger cohort would be beneficial. Furthermore, because of small fracture numbers, we were unable to estimate fracture risk at individual skeletal sites. We may have missed fractures

that were managed entirely outside the study region and as vertebral fracture outcomes were based on clinical indications, vertebral fracture incidence will have been under-estimated. These data may not be generalisable to other populations or ethnicities.

While recognising these constraints, however, we conclude that categories of decreasing BMD defined increasing risk of fracture, with advancing age amplifying this risk. Although men with severe deficits in BMD were at greatest risk, they accounted for only a small proportion of fractures. Utilisation of female reference data in some studies on men could be justified where use of a standard reference would preserve uniformity. However, if a single cut-point to define osteoporosis is to be used, this analysis would suggest that it may be preferable to use male reference data to avoid the burden of fractures shifting towards those with normal BMD and to preserve the phenomenon of the population burden of disease arising from the relatively large number of individuals who are at moderate risk. Fracture risk encompasses other dimensions beyond BMD that have been used in the development of fracture risk calculators such as age, prior fracture, falls and other clinical risk factors. Defining osteoporosis based on absolute fracture risk for men and women would incorporate contributions from multiple risk factors of which BMD is one component and would generate sex-specific BMD cut-points.

FINANCIAL DISCLOSURES

There are no competing interests. The study was funded by grants from the National Health and Medical Council (NHMRC 299831, 628582), The University of Melbourne Research Grant Scheme, American Society for Bone and Mineral Research (ASBMR), Perpetual Trustees, Amgen and the Geelong Region Medical Research Foundation, but

they played no part in the design or conduct of the study; collection, management, analysis, and interpretation of the data; or in preparation, review, or approval of the manuscript.

JAP was a recipient of the grants from the NHMRC (projects #251638, #299831, #628582), Geelong Regional Medical Research Foundation, Arthritis Foundation of Australia and Amgen (Europe) GmBH.

SLB was supported by NHMRC scholarship (#519404), and NHMRC Postdoctoral (Training) Fellowship (#1012472).

GCN was a recipient of the grants from the NHMRC (projects #251638, #299831, #628582), and Amgen (Europe) GmBH.

MAK was a recipient of the grants from the NHMRC (projects #251638, #299831, #628582), Geelong Regional Medical Research Foundation, and Amgen (Europe) GmBH.

All other authors state that they have no conflicts of interest.

REFERENCES

1. Murray CJ, Vos T, Lozano R, et al. (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 380:2197-2223.
2. Pasco JA, Seeman E, Henry MJ, Merriman EN, Nicholson GC, Kotowicz MA (2006) The population burden of fractures originates in women with osteopenia, not osteoporosis. Osteoporos Int 17:1404-1409.
3. Siris ES, Chen YT, Abbott TA, Barrett-Connor E, Miller PD, Wehren LE, Berger ML (2004) Bone mineral density thresholds for pharmacological intervention to prevent fractures. Arch Intern Med 164:1108-1112.
4. Australian Government Department of Health and Ageing (2005) A national action plan for osteoarthritis, rheumatoid arthritis and osteoporosis. Canberra: DoHA.
5. National Health Priority Action Council (2006) National service improvement framework for osteoarthritis, rheumatoid arthritis and osteoporosis. Canberra: Australian Government Department of Health and Ageing.
6. Ebeling PR (2008) Clinical practice. Osteoporosis in men. N Engl J Med 358:1474-1482.
7. Henry MJ, Pasco JA, Nicholson GC, Kotowicz MA (2011) Prevalence of osteoporosis in Australian men and women: Geelong Osteoporosis Study. Med J Aust 195:321-322.
8. Sanders KM, Seeman E, Ugoni AM, Pasco JA, Martin TJ, Skoric B,

Nicholson GC, Kotowicz MA (1999) Age- and gender-specific rate of fractures in Australia: a population-based study. Osteoporos Int 10:240-247.

9. Otmar R, Reventlow SD, Nicholson GC, Kotowicz MA, Pasco JA (2012) General medical practitioners' knowledge and beliefs about osteoporosis and its investigation and management. Arch Osteoporos 7:107-114.

10. Otmar R, Morrow M, Reventlow SD, Nicholson GC, Kotowicz MA, Pasco JA (2012) A cultural models approach to osteoporosis prevention and treatment. Sage Open 2:2158244012464976.

11. Otmar R, Kotowicz MA, Brennan SL, Bucki-Smith G, Korn S, Pasco JA. Personal and psychosocial impacts of clinical fracture in men. J Men's Health. In Press.

12. Poor G, Atkinson E, Lewallen D, O'Fallon W, Melton LJ 3rd (1995) Age-related hip fractures in men: clinical spectrum and short-term outcomes. Osteoporos Int 5:419-426.

13. Center JR, Nguyen TV, Schneider D, Sambrook PN, Eisman JA (1999) Mortality after all major types of osteoporotic fracture in men and women: an observational study. Lancet 353:878-882.

14. Kanis JA, Bianchi G, Bilezikian JP, Kaufman JM, Khosla S, Orwoll E, Seeman E (2011) Towards a diagnostic and therapeutic consensus in male osteoporosis. Osteoporos Int 22:2789-98.

15. Pasco JA, Nicholson GC, Kotowicz MA (2012) Cohort profile: Geelong Osteoporosis Study. Int J Epidemiol 41:1565-1575.

16. Henry MJ, Pasco JA, Nicholson GC, Seeman E, Kotowicz MA (2000) Prevalence of osteoporosis in Australian women: Geelong Osteoporosis

Study. J Clin Densitom 3:261-268.

17. World Health Organisation Study Group (1994) Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Technical Report Series 843. Geneva, Switzerland.

18. Henry MJ, Pasco JA, Korn S, Gibson JE, Kotowicz MA, Nicholson GC (2010) Bone mineral density reference ranges for Australian men: Geelong Osteoporosis Study. Osteoporos Int 21:909-917.

19. Henry MJ, Pasco JA, Pocock NA, Nicholson GC, Kotowicz MA (2004) Reference ranges for bone densitometers adopted Australia-wide: Geelong Osteoporosis Study. Australas Radiol 48:473-475.

20. Pasco JA, Henry MJ, Gaudry TM, Nicholson GC, Kotowicz MA (1999) Identification of incident fractures: the Geelong Osteoporosis Study. Aust N Z J Med 29:203-206.

21. Pocock N, Culton N, Noakes K, Harmelin D (2000) Discordant normal ranges for femoral neck BMD in Australia. Bone 27:48S.

FIGURE LEGEND

Figure 1 Absolute 5-year risk for fracture in men is represented by the dark columns and the proportion of fractures arising from each category of BMD (defined by male reference data on the left and female reference data on the right) is represented by the pale columns.

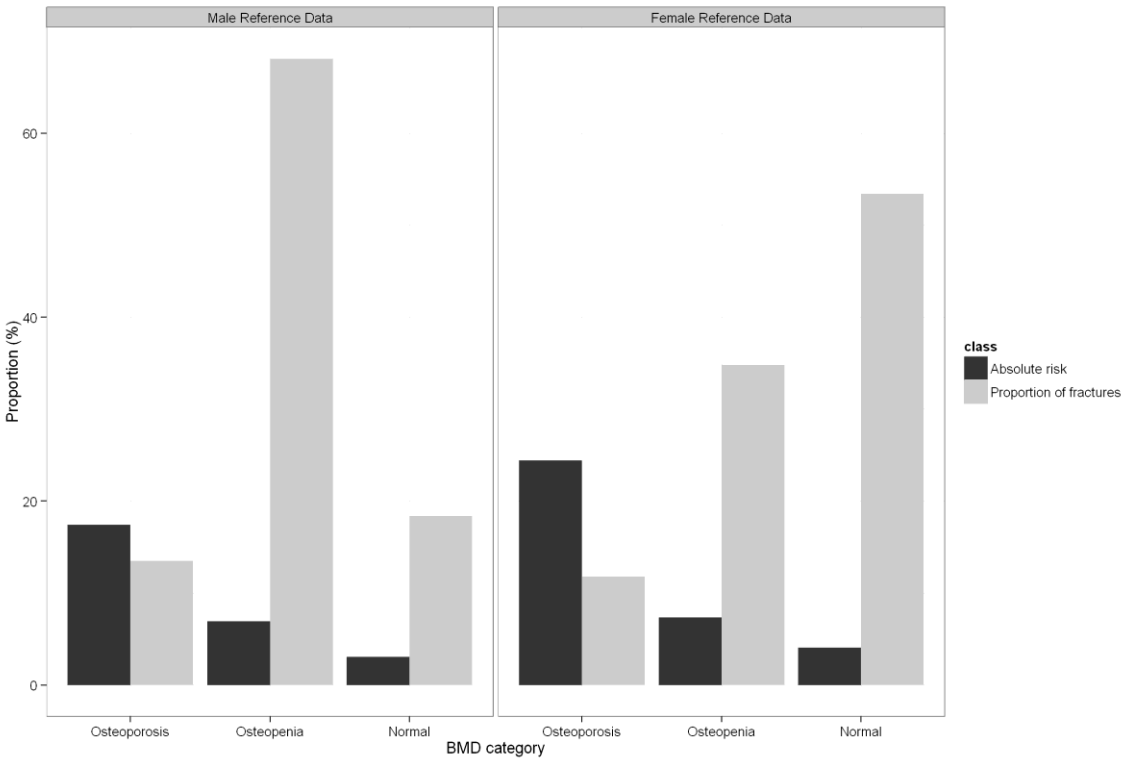
Table 1 Subject characteristics (raw data) for all men and categorised into groups with normal BMD, osteopenia and osteoporosis according to femoral neck BMD and classified using male and female reference data. Data are expressed as median (IQR), mean (±SD) or proportion n(%).

		Using male reference data			Using female reference data		
	All n = 619	Osteoporosis n = 55	Osteopenia n = 357	Normal BMD n = 207	Osteoporosis n = 31	Osteopenia n = 227	Normal BMD n = 361
Age (yr)	74.4 (67.4-81.5)	80.6 (74.6-84.6)	74.5 (67.8-82.0)	71.9 (64.9-78.3)	81.4 (74.4-85.2)	76.7 (69.7-82.8)	72.4 (65.9-78.8)
Weight (kg)	80.6 (±13.6)	72.6 (±13.3)	79.2 (±12.6)	85.1 (±13.9)	70.8 (±14.7)	77.2 (±12.1)	83.6 (±13.5)
Height (m)	1.72 (±0.07)	1.69 (±0.07)	1.72 (±0.06)	1.73 (±0.07)	1.68 (±0.08)	1.71 (±0.06)	1.73 (±0.07)
Follow-up (yr)	6.4 (4.9-7.2)	4.5 (2.2-6.4)	6.3 (4.8-7.1)	6.7 (5.3-7.3)	4.3 (2.1-6.2)	6.1 (4.5-7.0)	6.6 (5.3-7.3)
Incident fracture	63 (10.2%)	13 (23.6%)	36 (10.1%)	14 (6.8%)	11 (35.5%)	21 (9.3%)	31 (8.6%)
Prevalent fracture	137 (22.1%)	25 (45.5%)	85 (23.8%)	27 (13.0%)	14 (45.2%)	60 (26.4%)	63 (17.5%)

Table 2 Models 1-4 summarise results of the proportional hazards regression. BMD categories are defined using male reference data for model 1, and female reference data for model 2. BMD is introduced into the models as a continuous variable, expressed in standard deviations using male reference data in model 3 and female reference data in model 4. In all models, age (years) has been centred around the median* (ageC); interaction terms between ageC and BMD status have also been shown, where relevant.

	β	exp β	se (β)	z	p
MODEL 1					
Male reference data					
Osteopenia	0.70	2.02	0.40	1.78	0.08
Osteoporosis	1.53	4.64	0.55	2.81	0.00
Prevalent fracture	0.47	1.60	0.28	1.70	0.09
AgeC	0.17	1.19	0.05	3.74	0.00
Osteopenia*AgeC	-0.15	0.86	0.05	-3.07	0.00
Osteoporosis*AgeC	-0.13	0.88	0.06	-2.02	0.04
MODEL 2					
Female reference data					
Osteopenia	-0.06	0.94	0.29	-0.22	0.83
Osteoporosis	1.51	4.54	0.37	4.04	0.00
Prevalent fracture	0.47	1.60	0.28	1.68	0.09
AgeC	0.05	1.06	0.02	3.12	0.00
MODEL 3					
Male reference data					
BMD (SD_{male})	-0.47	0.63	0.16	-2.90	0.00
Prevalent fracture	0.48	1.61	0.28	1.72	0.09
AgeC	0.05	1.05	0.02	2.73	0.01
MODEL 4					
Female reference data					
BMD (SD_{female})	-0.39	0.68	0.13	-2.90	0.00
Prevalent fracture	0.48	1.61	0.28	1.72	0.09
AgeC	0.05	1.05	0.02	2.73	0.01

*74 years


Male Reference Data
Female Reference Data
Proportion (%)
60
40
20
0
Osteoporosis
Osteopenia
Normal
Osteoporosis
Osteopenia
Normal
BMD category
class
Absolute risk
Proportion of fractures

Author/s:
Pasco, JA; Lane, SE; Brennan, SL; Timney, EN; Bucki-Smith, G; Dobbins, AG; Nicholson, GC; Kotowicz, MA

Title:
Fracture risk among older men: osteopenia and osteoporosis defined using cut-points derived from female versus male reference data

Date:
2014-03-01

Citation:
Pasco, J. A., Lane, S. E., Brennan, S. L., Timney, E. N., Bucki-Smith, G., Dobbins, A. G., Nicholson, G. C. & Kotowicz, M. A. (2014). Fracture risk among older men: osteopenia and osteoporosis defined using cut-points derived from female versus male reference data. OSTEOPOROSIS INTERNATIONAL, 25 (3), pp.857-862. https://doi.org/10.1007/s00198-013-2561-9.