

## Bone density and fracture risk

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*Determining risk is the first step in deciding on appropriate management*

Osteoporosis, most simply and elegantly defined as “too little bone in the bone”, is generally the result of progressive bone loss which, for all practical purposes, starts at menopause in women and at about the age of 50 years in men. Because women have a lower bone organ density than men and then lose bone more rapidly,<sup>1</sup> and also because women live longer, osteoporotic fractures, particularly at the hip, affect more women than men in Western countries — there are 20 000 hip fractures per year in Australia, with women outnumbering men by a ratio of two to one. The immediate cost of osteoporosis in Australia has been estimated at nearly \$2 billion per year, with a further \$5–6 billion in indirect costs.<sup>2</sup>

Doctors are in a difficult position when it comes to managing osteoporosis and preventing fractures. As with most disorders, they

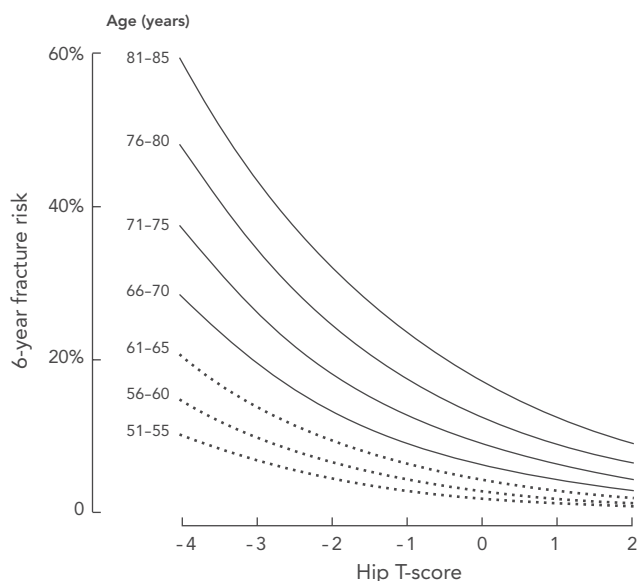
need to know the risk of an event such as fracture before reaching a treatment decision. They know that bone mineral density (BMD), measured by dual energy x-ray absorptiometry (DXA), is a major determinant of fracture risk, and they may have read that the risk goes up by a factor of 1.5–2 for every standard deviation fall in BMD<sup>3</sup> (which is actually incorrect, as shown below), but they have no means of converting this information into absolute numbers. This is partly because of long-standing confusion between odds and risk, exemplified by the fact that the relative risks quoted in the literature<sup>3</sup> are generally odds ratios or hazard ratios. The difference between odds and risk, well understood by professional statisticians, is not well understood by most clinicians. If 30 women out of 100 develop a fracture over a given period, the fracture risk is 30/100 or 0.30, but the fracture odds are 30/70 or 0.43 — a very different figure. At low levels of risk, say below 0.10, the difference between odds and risk is very small (one in 10 is close to one to nine) and can legitimately be ignored. However, as the risk increases, or the period over which it is calculated is extended, odds rise in a multiplicative fashion with fall in BMD, but risk does not. Odds have no upper limit, whereas risk can never rise above unity or rise by a multiplicative factor. A recent article sought to dispel this confusion by explaining the difference between fracture odds and fracture risk by reference to published data.<sup>4</sup> A follow-up article,<sup>5</sup> based on a prospective study carried out in Perth,<sup>6</sup> contained a graph representing true fracture risk as a function of age and BMD in women without prevalent fracture. For those who would like to calculate the 6-year risk, the formula is:

$$\text{Odds} = 0.025 \times 1.08^{\text{age} > 55} \times 1.49^{-\text{ve T-score}}$$

Risk is then derived from odds as:  $\text{odds}/(1 + \text{odds})$

We now wish to make this graph more readily available to doctors in Australia by reproducing it (Box). In women with any symptomatic prevalent fracture after the age of 50 years, 5 years should be added to the patient's age because, in the above study, the effect of prevalent fracture on fracture risk was equivalent to a 5-year increase in age.<sup>5</sup> (This, incidentally, shows the fallacy of using fracture as a substitute for densitometry in the diagnosis of osteoporosis, as is increasingly happening in Australia). Moreover,

**Six-year fracture risk in women aged over 50 years without prevalent fractures**



as men and women experience fractures at about the same BMD,<sup>7</sup> it is probably safe to use the same graph to calculate approximate fracture risk in men by adding one to the T-score. Needless to say, it is for the individual clinician, in consultation with the patient, to decide the level of risk at which any particular intervention is called for. An arguable policy is to use calcium supplementation (with vitamin D if indicated) to prevent bone loss in patients at low risk, and to reserve more expensive remedies for patients at high risk in whom osteoporosis is already established, especially as the pivotal studies for these remedies have been performed in patients with T-scores of -2 or lower.

We are aware that our fracture risks are somewhat higher than those derived from the Garvan Institute algorithm<sup>8</sup> which are in turn higher than those from the World Health Organization algorithm,<sup>9</sup> but the former appears to underestimate the effect of age, and the latter has already been criticised as being too low.<sup>10</sup> Only time will show which model is nearest the truth.

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### References

- 1 Trotter M, Broman GE, Peterson RR. Densities of bones of white and negro skeletons. *J Bone Joint Surg Am* 1960; 42: 50-58.
- 2 Access Economics. The prevalence, cost and disease burden of arthritis in Australia. Canberra: Access Economics, 2001.
- 3 Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* 1996; 312: 1254-1259.
- 4 Nordin BEC, Baghurst PA, Metcalfe A. The difference between hazard and risk in the relation between bone density and fracture. *Calcif Tissue Int* 2007; 80: 349-352.
- 5 Tucker G, Metcalfe A, Pearce C, et al. The importance of calculating absolute rather than relative fracture risk. *Bone* 2007; 41: 937-941.
- 6 Prince RL, Devine A, Dhaliwal SS, Dick IM. Effects of calcium supplementation on clinical fracture and bone structure: results of a 5-year, double-blind, placebo-controlled trial in elderly women. *Arch Intern Med* 2006; 166: 869-875.
- 7 De Laet CE, Van Hout BA, Burger H, et al. Hip fracture prediction in elderly men and women: validation in the Rotterdam study. *J Bone Miner Res* 1998; 13: 1587-1593.
- 8 Garvan Institute. Fracture risk calculator. <http://www.garvan.org.au/promotions/bone-fracture-risk> (accessed Jun 2008).
- 9 World Health Organization Collaborating Centre for Metabolic Bone Diseases, University of Sheffield, UK. FRAX WHO fracture risk assessment tool. <http://www.shef.ac.uk/FRAX/> (accessed Jun 2008).
- 10 Abrahamsen B, Vestergaard P, Rud B, et al. Ten-year absolute risk of osteoporotic fractures according to BMD T score at menopause: the Danish Osteoporosis Prevention Study. *J Bone Miner Res* 2006; 21: 796-800. □