

# Osteoporosis in frail older people

Frail older people have increased risks of osteoporosis, falling and fracture. Treatment approaches include strategies aiming to decrease the risk of subsequent fracture and minimise the escalation of frailty.

**CARYL A. NOWSON**

DipNutDiet, BSc, PhD

**LEON FLICKER**

MB BS, GDipEpid, PhD, FRACP

**MARIA A. FIATARONE  
SINGH MD, FRACP**

On behalf of the Medical  
and Scientific Committee  
of Osteoporosis Australia

Professor Nowson is Chair of Nutrition and Ageing in the Centre for Physical Activity and Nutrition Research, School of Exercise and Nutrition Sciences at Deakin University, Melbourne, Vic.

Professor Flicker is Director of the Western Australian Centre for Health & Ageing, WAIMR, University of Western Australia, and Geriatrician at Royal Perth Hospital, Perth, WA.

Professor Fiatarone Singh is Professor, Discipline of Exercise and Sports Science and John Sutton Chair of Exercise and Sport Science in the Faculty of Health Sciences at the University of Sydney, Sydney, NSW.

Osteoporosis often accompanies advanced frailty and any fragility fracture in this population is likely to have a profound impact on quality of life and may lead to permanent disability and even premature death. The multidimensional aspects of osteoporosis require a multidisciplinary integrated approach, including environmental, lifestyle, dietary and pharmacological interventions. Risk factors that have been identified are discussed, together with evidence-based recommendations for the prevention and management of osteoporosis in the frail elderly.

**Frailty**

Physiological reserve is often limited as people age. The progressive restriction of homeostatic reserve that is seen in all organ systems with ageing makes older people more vulnerable to relatively minor pathological conditions and is thought to underpin the syndrome of frailty. More advanced stages of frailty are associated with muscle weakness and increasing disability. Lower levels of frailty, while not disabling, may make individuals prone to future adverse health outcomes. Therefore, frailty mirrors the process of

**IN SUMMARY**

- Frail older people have reduced physiological reserves, often in multiple systems, and advanced stages are marked by reduced mobility and quality of life and increased mortality. Osteoporosis often accompanies advanced frailty and the loss of bone tissue and propensity to fracture may be considered frailty of the skeletal system.
- Frailty, insufficient physical activity, weight loss and low protein intake are associated with increased risk of osteoporosis, falling and fracture.
- Treatment of frail older people with osteoporosis aims to decrease the risk of subsequent fracture and minimise the escalation of frailty. Pharmacological options for reduction of fracture risk include bisphosphonates, strontium ranelate and teriparatide.
- Nonpharmacological strategies that can be applied almost universally to reduce frailty and falls risk include progressive resistance training, balance training, hip protectors, a nutritionally adequate diet, smoking cessation, moderation of alcohol intake and therapies for depression.
- The most robust results are achieved with centre-based exercise programs, and these programs are the best option for complicated and high-risk individuals. Appropriate home or community exercise programs can be carried out, with instruction and ongoing monitoring, if severe frailty and cognitive impairment are not present.<sup>1,2</sup>

osteoporosis, where loss of bone tissue and the accompanying micro-architectural tissue pathology does not cause any morbidity until a fracture takes place.

Between 6% and 25% of free-living individuals aged 65 years and older may be considered frail. The proportion increases to about 25 to 40% in those aged 80 years and above.<sup>3</sup>

Frailty is complex, is not clearly defined, and is frequently accompanied by a number of comorbidities. One common classification of frailty is characterised by the presence of three of the following five features:<sup>4</sup>

- unintentional weight loss
- self-reported exhaustion
- weakness
- slow walking speed
- low physical activity.

Frail individuals often have a slow and unsteady gait, and are more likely to experience impaired cognition and depression and die earlier. Sarcopenia and osteopenia, with an increased susceptibility to fracture, are common features of advanced frailty.<sup>5</sup> A post-inflammatory process and a rise in inflammatory catabolic cytokines seem to accompany the development of frailty in the elderly, potentially via effects on muscle mass and bone density.<sup>6</sup> Thus, the syndrome of osteoporotic frailty may be seen as an increased risk for falling, superimposed on a predisposition to injury of soft tissue or bone; one without the other may be insufficient to result in a fragility fracture. Pathological changes such as microfractures occur due to senescence of cellular signalling pathways, weakening the bone prior to sustaining an overt fracture.<sup>7</sup> Alternatively, with ageing and inactivity the diameter of long bones may enlarge and the cortices thin, resulting in maintenance of bone strength at the expense of the propensity to fracture on sideways impact.<sup>8</sup>

### Frailty and fracture

In Australia, the most prevalent risk factors for hip fracture have been found to be low bone mineral density (BMD), postural instability and/or quadriceps weakness, a history of falls and prior fracture.<sup>9</sup>

People in residential care are especially at risk for osteoporotic fractures, with reported prevalence of osteoporosis and/or fragility fractures in

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the order of 85.8% for institutionalised women over 85 years of age.<sup>10</sup> This population is particularly at risk because of impaired mobility, inactivity, cognitive impairment, polypharmacy and use of psychotropic medications as part of polypharmacy, poor nutrition and limited sun exposure, all of which are risk factors for fragility fracture.

Previous reports have shown that osteoporosis is underdiagnosed and not adequately treated in residential care. For example, in the USA only 55% of women with osteoporosis were receiving

calcium and only 42% were receiving vitamin D in a long-term care establishment, and in aged care facilities in Sydney, only 10.3% received vitamin D supplementation.<sup>11,12</sup>

### Obesity, body weight and weight loss

Weight loss in older people, even when 'intentional', is associated with increased mortality, and is one of the characteristics of frailty.<sup>13</sup> In those over the age of 75 years, being overweight confers some survival benefit, with reduced mortality.<sup>14</sup> Weight loss in these people could be detrimental.<sup>15</sup> Low body weight is associated with poor physical function, disability and poor muscle strength.<sup>16,17</sup> Being underweight is also associated with increased mortality, increased risk of hip fracture and reduced mobility.

Weight loss in older people is commonly characterised by loss of muscle mass and muscle strength, which defines age-related sarcopenia.<sup>18</sup> The pathophysiology of sarcopenia in the elderly is complex. Muscle mass decrease is directly responsible for functional impairment, with loss of strength, balance and aerobic capacity, increased likelihood of falls and loss of independence. An inadequate intake of energy and protein will contribute to loss of muscle and function, and there are considerable overlaps between cachexia and sarcopenia in older patients.<sup>19</sup>

In frail elders, the combination of sarcopenia and obesity, termed 'sarcopenic obesity' or masked sarcopenia, can co-exist with undernutrition. These two conditions may potentiate each other to impair physical function and increase risk of injurious falls, morbidity and mortality.

Other dietary factors may impact on loss of muscle mass and function, in particular vitamin D. Low serum vitamin D levels have also been linked with lower walking speeds, particularly in fast-pace walking,<sup>20</sup> and also with cognitive impairment and depressive symptoms, both of which are risk factors for hip fracture and

frailty. Older adults with hip fracture commonly present with sarcopenia and/or sarcopenic obesity and vitamin D deficiency.<sup>21</sup> Furthermore, muscle weakness, undernutrition and low vitamin D levels predict recurrent injurious falls.<sup>22</sup>

### Role of nutrition in prevention of osteoporosis

Low muscle mass, low energy expenditure and reduced physical activity contribute to the poor appetite in many frail individuals. The poor appetite usually results in inadequate intakes of both macro and micronutrients. Weight loss occurs when there is an inadequate energy intake, and this results in loss of lean tissue (muscle and bone) as well as loss of fat. The loss of lean tissue contributes to reduced physical activity, and when this inactivity is accompanied by the stress of disease, the rate of muscle protein catabolism can increase several fold.<sup>23</sup> Protein requirements are increased by about 20% in older people, and adequate protein is important in minimising bone loss and facilitating calcium absorption.<sup>24</sup> For example, supplementation with a high protein drink after hip fracture has been found to reduce bone loss and the length of hospitalisation.<sup>25</sup>

By contrast, there is a reduction in energy requirements with increasing age because of reduced basal metabolic rate (BMR), reduced lean mass and reduced levels of physical activity. As age increases, there is an increased requirement for several nutrients in addition to protein, including calcium, riboflavin (vitamin B<sub>2</sub>), vitamin B<sub>6</sub> and vitamin D. Accordingly, it is difficult for older people who are consuming relatively low energy diets or making poor dietary choices with low nutrient density to meet their nutrient requirements from food.<sup>26</sup> One large longitudinal study found that a low intake of more than three nutrients (poor nutritional score) was significantly associated with frailty, independent of energy intake and other potential confounders.<sup>27</sup>

The ability to meet dietary requirements for older people may be further compromised by drug–nutrient interactions or by the presence of chronic diseases that affect absorption, transportation, metabolism and excretion of essential nutrients. The ageing gastrointestinal tract becomes less efficient in absorbing vitamin B<sub>12</sub>, vitamin D, calcium and iron,<sup>26</sup> and nonthiazide diuretics can result in urinary losses of potassium, calcium and magnesium. People in residential care facilities are particularly at risk of malnutrition, with the prevalence of malnutrition estimated to be between 10 and 50% of residents, depending on the survey methodology.<sup>28,29</sup> In an Australian sample population in residential care, 46% of residents had low serum zinc (below 10.7 µmol/L) and only 7% of residents did not have a deficiency or insufficiency of at least one of body weight, serum 25-hydroxyvitamin D, albumin, folate, vitamin B<sub>12</sub> or zinc.<sup>30</sup>

Common medical conditions associated with ageing, environmental issues relating to access to food and cooking facilities, social isolation and low income can further exacerbate nutritional problems in both community and institutional settings. Chronic diseases can also be associated (causally or consequentially) with reduced appetite, difficulties in self-feeding, poor mobility, dementia and depression.<sup>31–34</sup> Depression is common in older people and although reported prevalence rates of depression vary, an average prevalence of 13.5% has been estimated for all clinically relevant depressive syndromes, with higher prevalence rates for women and among older people living under adverse socioeconomic circumstances.<sup>35</sup> Notably, depression is the most commonly diagnosed cause of weight loss in older persons.<sup>34</sup>

### Vitamin D

Vitamin D insufficiency or deficiency is highest in the elderly and those who are housebound, hospitalised or in

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residential care, with vitamin D deficiency rates ranging from 45 to 75%.<sup>22,36,37</sup> Vitamin D synthesis in the skin in response to sunlight exposure decreases with age.<sup>38</sup> Also, many frail older people are confined indoors most of the time.

Apart from the well-recognised role of vitamin D in maintenance of skeletal health, reduced vitamin D status has been associated with cognitive impairment,<sup>39</sup> which has been related to gait control in older adults increasing risk of falls

and thereby fractures. Cross-sectionally, vitamin D deficiency is associated with impaired neuromuscular function and possibly impaired balance but this is not a consistent finding.<sup>40,41</sup>

It is not possible to meet vitamin D

### Strategies for preventing falls, disability and fractures in frail older people

#### Lifestyle strategies

- Encourage being active every day and participation in weight-bearing, weight-lifting and balance-enhancing activities.
  - Progressive resistance training: two to three days per week, centre-based if possible. Although some older people may not be able to access centre-based programs, many home-based programs can be carried out with minimal equipment after appropriate instruction.<sup>1,2</sup>
  - Balance training: activities that challenge and thereby improve static and dynamic balance can be carried out at home or under supervision (recommended until safety and competence is demonstrated). Examples of such activities are standing on one leg, moving to the limits of sway, reducing hand support and visual input, tandem walking, sideways walking and maintaining balance on a compliant or moving surface.
  - High impact exercise: high impact activities such as jumping are appropriate for individuals without limiting arthritis or acute fracture.
  - Low intensity physical activity: although available and often feasible for frail older people, walking and seated callisthenics have not been shown to be specifically beneficial for bone health or fracture risk reduction. These activities do, however, have some benefits compared with inactivity.
- Encourage maintenance of body weight within a healthy weight range.
  - If BMI is below 18, aim to increase body weight.
  - If BMI is 20 or higher, maintain body weight.
  - Referral to a dietitian is recommended to increase body weight because it is very difficult for frail older people to gain weight. High-energy fluid supplements need to be used appropriately to ensure they do not displace food. Resistance training is anabolic and has been shown to improve nutritional intake and status and complements dietary interventions.
- Encourage a nutritionally adequate diet, with sufficient calcium, energy and protein. Provide vitamin D supplementation if required.
  - Maintain adequate dietary calcium intake, i.e. between 1100 and 2500 mg a day. This is equivalent to at least three cups/serves of milk or two cups of calcium-fortified milk each

day. If this intake is not possible then calcium supplements should be used to achieve an intake of at least 1100 mg/day.

- Maintain adequate dietary protein intake, i.e. at least 1.6 g protein per kg of body weight each day.

- Consume a diet based on a wide variety of foods rich in nutrients, including vitamins and minerals, e.g. fruits and vegetables, fish, chicken, red meat and polyunsaturated and monounsaturated fats.

- Maintain adequate vitamin D status, i.e. 25-hydroxyvitamin D levels of at least 50 nmol/L. Although epidemiological evidence indicates that higher levels may be beneficial, there are no randomised controlled trials as yet to confirm the health benefits of maintaining higher serum levels. Most people will not have sufficient sun exposure to maintain adequate vitamin D levels and will require vitamin D supplementation (1000 IU per day cholecalciferol) as few foods contain vitamin D.

- Encourage smoking cessation and moderation of alcohol intake.

#### Environmental and medical strategies

- Test for vitamin D deficiency in high risk older people and provide supplements if required.
- Minimise environmental hazards for falls.
- Encourage participation in group activities centred around physical activity and the enjoyment of eating.
- Use nonpharmacological strategies to reduce depression, i.e. counselling, exercise, cognitive behavioural therapy. Pharmacological treatment with antidepressive agents is also an option, although sedation should be avoided.
- Ensure access of older people to retail food outlets, cooking facilities and community support schemes, as required.
- Encourage use of hip protectors. They are effective if worn, but compliance in the community is poor.
- Prescribe specific pharmacological agents to reduce risk of further fractures. Options include bisphosphonates, strontium ranelate and teriparatide. There is substantial evidence of fracture reduction in people over the age of 75 years with use of these medications, although not necessarily in frail older people with comorbidities.

requirements from food sources, as few foods contain vitamin D. Vitamin D supplementation (in combination with calcium supplementation) has been found to be effective in reducing rates of falls and fractures, particularly in the frail older group.<sup>36,42-44</sup> Vitamin D treatment after hip fracture has recently been shown to reduce complications leading to hospital readmission.<sup>45</sup>

The recommended daily dose of vitamin D to reduce fracture risk is at least 1000 IU (25 µg) of cholecalciferol.<sup>46</sup> Vitamin D supplements are well tolerated. Larger dose supplements, which need to be taken less frequently, are effective and represent a lower patient burden, but are not readily available in Australia.<sup>47</sup> A recent study, however, has shown that very large doses (500,000 IU) given annually appear to have adverse effects.<sup>48</sup>

### Calcium

There is a reduction in calcium absorption with age.<sup>49</sup> It is difficult for older frail people with reduced energy intakes to consume the recommended intake of calcium from dietary sources. For women over the age of 50 years and men over the age of 70 years the Estimated Average Requirement is 1100 mg of calcium a day, and the Recommended Dietary Intake is 1300 mg a day.<sup>24</sup> To achieve this intake at least three to four serves of dairy products (three to four glasses of milk a day) would be required, which is not possible for many frail older people.

The range of calcium fortified products now available in Australia may assist people who are unable to consume the recommended quantity of dairy products required to meet calcium requirements. Foods in this range include orange juice, bread and milk.

If adequate calcium cannot be achieved from dietary sources, calcium supplements (combined with vitamin D supplements) are recommended. Calcium supplementation has been found to reduce rates of fractures, particularly in people who



Figure 1. Hip extension is one of many resistance training exercises that can be carried out by patients with osteoporosis. Centre-based exercise programs generally give better results than home- or community-based exercise programs.

are elderly, in residential care or have low calcium intakes.<sup>50</sup> However, compliance with calcium supplements is poor in the long term because of gastrointestinal side effects and difficulties in swallowing tablets. Although an increased risk of cardiovascular disease has been reported with calcium supplementation,<sup>51</sup> this is not a consistent finding and calcium supplementation is recommended for older frail people who have calcium intakes much lower than the recommended intakes.

### Frailty and falls

Most (more than 90%) nonvertebral fractures are preceded by a fall. Recurrent falls are a manifestation of increasing frailty. Increasing frailty affects balance, dynamic postural control and locomotion

until a threshold is reached and relatively minor external perturbations result in a fall. If left untreated, such a falls risk can result in increasing curtailment of the activities of daily life, cumulating in further weakness and frailty.

Falls are common and occur in one-third of women and one-fifth of men over the age of 70 years. The common diseases of old people, such as dementia, osteoarthritis and stroke, increase the risk of both frailty and falls. Older age, congestive heart failure, poorer quality of life and poorer nutritional status have recently been identified as independent risk factors for recurrent and injurious falls among people with a previous hip fracture.<sup>26</sup> The risk of falls can be reduced by decreasing the number of environmental hazards, correcting visual deficits,



Figure 2. Balance enhancing exercises such as tandem or heel-to-toe walking can reduce the risk of falling.

reducing the number of medications (including psychoactive medications), adopting an exercise program with the goals of increasing strength and balance, and reducing the dose of psychoactive medications (see the box on page 22).<sup>52,53</sup>

Progressive resistance training (PRT) may be beneficial in older people by increasing strength (it has to be progressive in the sense of getting progressively harder to continue to improve bone health).<sup>54</sup> This type of resistance, or strength, training is intended for both the fit and the frail elderly, and has successfully been carried out in home settings with minimal equipment and minimal supervision after appropriate instruction.<sup>1,2</sup> The most robust results, however, are achieved with centre-based exercise programs, and these programs are the best options for high-risk individuals (Figure 1). There are some community-based exercise programs that

include PRT for seniors, but many more are needed. Modifications needed for home-based programs involve altering the level of supervision, the need for seated versus standing postures, the type of equipment and the use of low-impact modes of implementation.

Balance training exercises such as standing on one leg, tandem walking (heel-to-toe walking) and sideways walking improve balance and mobility and reduce fear of falling (Figure 2). Like PRT, balance training can be carried out in the home or as part of a centre-based program.

Although the evidence for reduction of subsequent falls using these interventions is strong, achieving widespread translation into services and the community generally have been difficult. Moreover, they have not been shown to reduce fracture risk in the community, it is not clear if they are effective for hospital inpatients and the evidence for effectiveness in residents in aged care facilities is mixed.<sup>55</sup> At the present time, best practice interventions are not consistently delivered to community dwelling older people at the highest risk, and few programs are delivered to those at lower risk.<sup>56</sup> Interventions need to be tailored to account for medical comorbidities such as the reduced cardiorespiratory reserve associated with cardiac and respiratory conditions; this generally can be achieved.<sup>1,2</sup>

### Pharmacotherapy

As with every disease, any modifiable risk factors for osteoporosis and frailty should be sought and treated appropriately. Diseases that may cause osteoporosis (e.g. thyrotoxicosis) should be treated, and the use of medications known to increase the risk of osteoporosis (e.g. corticosteroids) should be minimised to the lowest dose clinically required. Older frail people are at increased risk of treatment side effects, and before embarking on treatment consideration should be given to the patient's life expectancy,

ability to comply with therapy (particularly in view of cognitive impairment) and other comorbidities that might increase the risk of therapy (e.g. oesophageal reflux and bisphosphonate therapy).

Besides calcium and vitamin D supplements, specific pharmacotherapy options for osteoporosis in frail older patients include hormone therapy (HT), bisphosphonates, selective oestrogen receptor modulating drugs (SERMs; e.g. raloxifene), strontium ranelate and teriparatide. HT is now rarely used in women of advanced years since a large randomised trial demonstrated an overall increase in risks compared with benefits, although there was no evidence of any adverse effect on mortality outcome.<sup>57</sup> Treatment in this population must be guided by the existing evidence, a patient's preference and capacity for compliance, the risk of adverse events and cost. Unfortunately none of these agents have been evaluated specifically in frail older people. Alendronate, risedronate and strontium ranelate have been tested in large numbers of older people, including those over the age of 80 years, for several years of treatment. Teriparatide has been assessed for a shorter period than the other agents.<sup>58</sup> Zoledronic acid has been evaluated in older people after hip fractures, a group of patients very likely to have moderate to severe levels of frailty.<sup>59</sup> It is important to correct calcium and vitamin D deficiencies in these patients before the administration of bisphosphonates, especially zoledronic acid, because they are at high risk of osteomalacia.

It seems likely that there are potential benefits from fracture reduction for those frail older people at high risk of subsequent fracture, but these benefits must be balanced by an increased risk of adverse events. Monitoring of treatment efficacy should be individualised. BMD remeasurement should be considered if it will influence ongoing management, noting that hip dual energy x-ray absorptiometry (DXA) may be more useful than spinal

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DXA in older people as the results of the latter may be artefactually elevated because of spinal fractures and osteoarthritis. Patients with recurrent fractures should, after secondary causes have been excluded, be re-evaluated for pharmacotherapy adherence difficulties, falls risk assessment and prevention strategies.

### Recommendations

A low level of exercise, a tendency to fall and low protein intake tend to cluster in very frail older people. Exercise can help in preserving and increasing muscle mass and strength, as well as increasing appetite.<sup>54</sup> Appropriate nutrition, particularly adequate energy, protein and calcium, and maintaining adequate vitamin D status should be recommended for all people to help minimise frailty. These strategies are also beneficial in treating frailty when combined with treatment of any underlying diseases, particularly depressive illness.

Progressive resistance training appears to be possible for many elderly individuals.<sup>60</sup> Resistance training increases bone and muscle mass and strength, and appears to ameliorate or reverse important physical and psychological aspects of frailty, including depression and low self-efficacy.<sup>5</sup> Balance exercises may also have a role in reducing falls risk.<sup>61</sup> In older people, evidence suggests that increased dietary protein combined with high intensity resistance exercise training can increase muscle mass.<sup>62</sup> It has been shown that even in residential care settings, a resistance exercise program increased muscle strength, indicating that treatment strategies can be effective in this most frail group.<sup>54</sup>

Multifactorial preventative strategies to reduce falls and fractures are often indicated. The use of hip protectors and adequate treatment of osteoporosis are also warranted in people at high risk. As with pharmacological treatments, there are compliance issues with the long-term use of hip protectors. If a hip

fracture occurs, the most important prognostic factors associated with rehabilitation success of older patients are cognitive function, nutritional status, pre-fracture functional level and depression. Of these, depression and nutritional status are amenable to interventions, and early intervention may improve rehabilitation outcome.<sup>63</sup> Progressive resistance training may be particularly beneficial

in older people in increasing strength even after fracture.<sup>64</sup> Specific pharmacotherapy to prevent fractures must be considered in all frail older people who have osteoporosis.

One of the key challenges in caring for older frail people is keeping them interested in food when there is a general reduction in appetite, a reduced drive to eat and a high incidence of depression.

Innovative strategies to improve the eating environment and the taste and variety of foods provided can result in key improvements in risk factors for fractures, particularly maintaining body weight. Such strategies have been found to be effective in residential care.<sup>65,66</sup>

Similarly, opportunities to be optimally physically active in the community, the home and even in residential care

settings should be enhanced. This requires alterations in the built environment, removal of policies restricting use of stairs or outdoor ambulation in institutions, and provision of access to suitable exercise facilities and trainers, for example. The multidimensional syndrome of osteoporotic fracture in frail older adults needs a similarly integrated approach to prevention and management

if the incidence and morbidity of this prevalent condition is to be reduced.

## Conclusion

Frail older people are likely to have osteoporosis and to be at increased risk of falls and fractures. There are a range of lifestyle and pharmacological strategies available to reduce risk of falls and fractures. These include specific types of physical activity (progressive resistance training and balance training), management of polypharmacy, smoking cessation, moderation of alcohol intake and a nutritionally adequate diet. The diet assists in maintaining body weight and may also include nutritional supplements to ensure sufficiency of vitamin D and calcium. There are also several pharmacological options to reduce bone loss. **MT**

## References

*A list of references is available on request to the editorial office.*

**COMPETING INTERESTS:** None.

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**CARYL A. NOWSON** DipNutDiet, BSc, PhD **LEON FLICKER** MB BS, GDipEpid, PhD, FRACP **MARIA A. FIATARONE SINGH** MD, FRACP

## References

1. Fiatarone Singh M. Exercise and osteoporotic fracture prevention: Part 2: prescribing exercise. *Med Today* 2007; 8(1): 31-41.
2. Fiatarone Singh M. Exercising to prevent osteoporotic fractures: patient handout. *Med Today* 2007; 8(3): 69-74.
3. Strandberg TE, Pitkala KH. Frailty in elderly people. *Lancet* 2007; 369: 1328-1329.
4. Fried LP, Young Y, Rubin G, Bandeen-Roche K. Self-reported preclinical disability identifies older women with early declines in performance and early disease. *J Clin Epidemiol* 2001; 54: 889-901.
5. Vanitallie TB. Frailty in the elderly: contributions of sarcopenia and visceral protein depletion. *Metabolism* 2003; 52(10 Suppl 2): 22-26.
6. Roubenoff R. Catabolism of aging: is it an inflammatory process? *Curr Opin Clin Nutr Metab Care* 2003; 6: 295-299.
7. Seeman E, Delmas PD. Bone quality – the material and structural basis of bone strength and fragility. *N Engl J Med* 2006; 354: 2250-2261.
8. Seeman E. Periosteal bone formation – a neglected determinant of bone strength. *N Engl J Med* 2003; 349: 320-323.
9. Nguyen ND, Pongchaiyakul C, Center JR, Eisman JA, Nguyen TV. Identification of high-risk individuals for hip fracture: a 14-year prospective study. *J Bone Miner Res* 2005; 20: 1921-1928.
10. Zimmerman SI, Girman CJ, Buie VC, et al. The prevalence of osteoporosis in nursing home residents. *Osteoporos Int* 1999; 9: 151-157.
11. Kamel HK. Underutilization of calcium and vitamin D supplements in an academic long-term care facility. *J Am Med Dir Assoc* 2004; 5: 98-100.
12. Zochling J, Chen JS, Seibel M, et al. Calcium metabolism in the frail elderly. *Clin Rheumatol* 2005; 24: 576-582.
13. Corrada MM, Kawas CH, Mozaffar F, Paganini-Hill A. Association of body mass index and weight change with all-cause mortality in the elderly. *Am J Epidemiol* 2006; 163: 938-949.
14. Reis JP, Macera CA, Araneta MR, Lindsay SP, Marshall SJ, Wingard DL. Comparison of overall obesity and body fat distribution in predicting risk of mortality. *Obesity (Silver Spring)* 2009; 17: 1232-1239.
15. Miller S, Wolfe R. The danger of weight loss in the elderly. *J Nutr Health Aging* 2008; 12: 487-491.
16. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *J Am Geriatr Soc* 2002; 50: 889-896.
17. Rantanen T, Penninx BW, Masaki K, Lintunen T, Foley D, Guralnik JM. Depressed mood and body mass index as predictors of muscle strength decline in old men. *J Am Geriatr Soc* 2000; 48: 613-617.
18. Bales CW, Ritchie CS. Sarcopenia, weight loss, and nutritional frailty in the elderly. *Annu Rev Nutr* 2002; 22: 309-323.
19. Muscaritoli M, Anker SD, Argiles J, et al. Consensus definition of sarcopenia, cachexia and pre-cachexia: Joint document elaborated by Special Interest Groups (SIG) ‘cachexia-anorexia in chronic wasting diseases’ and ‘nutrition in geriatrics’. *Clin Nutr* 2010; 29: 154-159.
20. Annweiler C, Schott AM, Montero-Odasso M, et al. Cross-sectional association between serum vitamin D concentration and walking speed measured at usual and fast pace among older women: the EPIDOS study. *J Bone Miner Res* 2010; 25: 1858-1866.
21. Fiatarone SM, Singh N, Hansen R, et al. Methodology and baseline characteristics for the Sarcopenia and Hip Fracture study: a 5-year prospective study. *J Gerontol A Biol Sci Med Sci* 2009; 64: 568-574.
22. Lloyd BD, Williamson DA, Singh NA, et al. Recurrent and injurious falls in the year following hip fracture: a prospective study of incidence and risk factors from the Sarcopenia and Hip Fracture study. *J Gerontol A Biol Sci Med Sci* 2009; 64: 599-609.
23. Paddon-Jones D. Interplay of stress and physical inactivity on muscle loss: nutritional countermeasures. *J Nutr* 2006; 136: 2123-2126.
24. NHMRC. Nutrition reference values for Australia and New Zealand including recommended dietary intakes. Canberra: Commonwealth Department of Health and Ageing; 2006.
25. Schurch MA, Rizzoli R, Slosman D, Vadas L, Vergnaud P, Bonjour JP. Protein supplements increase serum insulin-like growth factor-I levels and attenuate proximal femur bone loss in patients with recent hip fracture. A randomized, double-blind, placebo-controlled trial. *Ann Intern Med* 1998; 128: 801-809.
26. Russell RM. The aging process as a modifier of metabolism. *Am J Clin Nutr* 2000; 72(2 Suppl): 529S-532S.
27. Bartali B, Frongillo EA, Bandinelli S, et al. Low nutrient intake is an

- essential component of frailty in older persons. *J Gerontol A Biol Sci Med Sci* 2006; 61: 589-593.
28. Pauly L, Stehle P, Volkert D. Nutritional situation of elderly nursing home residents. *Z Gerontol Geriatr* 2007; 40: 3-12.
  29. Grieger JA, Nowson CA. Nutrient intake and plate waste from an Australian residential care facility. *Eur J Clin Nutr* 2007; 61: 655-663.
  30. Grieger J, Nowson C, Ackland ML. Anthropometric and biochemical markers for nutritional risk among residents within an Australian residential care facility. *Asia Pac J Clin Nutr* 2007; 16: 178-186.
  31. Mowe M, Bohmer T. Reduced appetite. A predictor for undernutrition in aged people. *J Nutr Health Aging* 2002; 6: 81-83.
  32. Berkhout AM, Cools HJ, van Houwelingen HC. The relationship between difficulties in feeding oneself and loss of weight in nursing-home patients with dementia. *Age Ageing* 1998; 27: 637-641.
  33. Stewart R, Masaki K, Xue QL, et al. A 32-year prospective study of change in body weight and incident dementia: the Honolulu-Asia aging study. *Arch Neurol* 2005; 62: 55-60.
  34. Morley JE, Kraenzle D. Causes of weight loss in a community nursing home. *J Am Geriatr Soc* 1994; 42: 583-585.
  35. Beekman AT, Copeland JR, Prince MJ. Review of community prevalence of depression in later life. *Br J Psychiatry* 1999; 174: 307-311.
  36. Flicker L, Mead K, MacInnis RJ, et al. Serum vitamin D and falls in older women in residential care in Australia. *J Am Geriatr Soc* 2003; 51: 1533-1538.
  37. Sambrook PN, Chen JS, March LM, et al. Serum parathyroid hormone predicts time to fall independent of vitamin D status in a frail elderly population. *J Clin Endocrinol Metab* 2004; 89: 1572-1576.
  38. MacLaughlin J, Holick MF. Aging decreases the capacity of human skin to produce vitamin D3. *J Clin Invest* 1985; 76: 1536-1538.
  39. Annweiler C, Schott AM, Allali G, et al. Association of vitamin D deficiency with cognitive impairment in older women: cross-sectional study. *Neurology* 2009; 74: 27-32.
  40. Dhesi JK, Bearne LM, Moniz C, et al. Neuromuscular and psychomotor function in elderly subjects who fall and the relationship with vitamin D status. *J Bone Miner Res* 2002; 17: 891-897.
  41. Annweiler C, Schott AM, Berrut G, Fantino B, Beuchet O. Vitamin D-related changes in physical performance: a systematic review. *J Nutr Health Aging* 2009; 13: 893-898.
  42. Flicker L, MacInnis RJ, Stein MS, et al. Should older people in residential care receive vitamin D to prevent falls? Results of a randomized trial. *J Am Geriatr Soc* 2005; 53: 1881-1888.
  43. Bischoff-Ferrari HA, Willett WC, Wong JB, Giovannucci E, Dietrich T, Dawson-Hughes B. Fracture prevention with vitamin D supplementation: a meta-analysis of randomized controlled trials. *JAMA* 2005; 293: 2257-2264.
  44. Chapuy M, Arlot M, Duboeuf F, Crouzet B, Arnaud S, Delmas P, et al. Vitamin D3 and calcium to prevent hip fractures in the elderly. *N Engl J Med* 1992; 327: 1637-1642.
  45. Bischoff-Ferrari HA, Dawson-Hughes B, Platz A, et al. Effect of high-dosage cholecalciferol and extended physiotherapy on complications after hip fracture: a randomized controlled trial. *Arch Intern Med* 2010; 170: 813-820.
  46. Working Group of the Australian and New Zealand Bone and Mineral Society, Endocrine Society of Australia and Osteoporosis Australia. Vitamin D and adult bone health in Australia and New Zealand: a position statement. *Med J Aust* 2005; 182: 281-285.
  47. Wigg AE, Prest C, Slobodian P, Need AG, Cleland LG. A system for improving vitamin D nutrition in residential care. *Med J Aust* 2006; 185: 195-198.
  48. Sanders KM, Stuart AL, Williamson EJ, et al. Annual high-dose oral vitamin D and falls and fractures in older women: a randomized controlled trial. *JAMA* 2010; 303: 1815-1822.
  49. Nordin BE, Need AG, Morris HA, O'Loughlin PD, Horowitz M. Effect of age on calcium absorption in postmenopausal women. *Am J Clin Nutr* 2004; 80: 998-1002.
  50. Tang BM, Eslick GD, Nowson C, Smith C, Bensoussan A. Use of calcium or calcium in combination with vitamin D supplementation to prevent fractures and bone loss in people aged 50 years and older: a meta-analysis. *Lancet* 2007; 370: 657-666.
  51. Bolland MJ, Avenell A, Baron JA, et al. Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis. *BMJ* 2010; 341: c3691.
  52. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc* 2009; 41: 1510-1530.
  53. Kannus P, Sievanen H, Palvanen M, Jarvinen T, Parkkari J. Prevention of falls and consequent injuries in elderly people. *Lancet* 2005; 366: 1885-1893.
  54. Fiatarone MA, O'Neill EF, Ryan ND, et al. Exercise training and nutritional supplementation for physical frailty in very elderly people. *N Engl J Med* 1994; 330: 1769-1775.
  55. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev* 2009(2): CD007146.
  56. Salter AE, Khan KM, Donaldson MG, et al. Community-dwelling seniors who present to the emergency department with a fall do not receive guideline care and their fall risk profile worsens significantly: a 6-month prospective study. *Osteoporos Int* 2006; 17: 672-683.
  57. Rossouw JE, Anderson GL, Prentice RL, et al. Risks and benefits of estrogen plus progestin in healthy postmenopausal women: principal results from the Women's Health Initiative randomized controlled trial. *JAMA* 2002; 288: 321-333.
  58. Inderjeeth CA, Foo AC, Lai MM, Glendenning P. Efficacy and safety of pharmacological agents in managing osteoporosis in the old old: review of the evidence. *Bone* 2009; 44: 744-751.
  59. Lyles KW, Colon-Emeric CS, Magaziner JS, et al. Zoledronic acid and clinical fractures and mortality after hip fracture. *N Engl J Med* 2007; 357: 1799-1809.
  60. American Geriatrics Society BGS, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guideline for the prevention of falls in older persons. *J Am Geriatr Soc* 2001; 49: 664-672.
  61. Morgan RO, Virnig BA, Duque M, Abdel-Moty E, Devito CA. Low-intensity exercise and reduction of the risk for falls among at-risk elders. *J Gerontol A Biol Sci Med Sci* 2004; 59: 1062-1067.
  62. Evans WJ. Protein nutrition, exercise and aging. *J Am Coll Nutr* 2004; 23(6 Suppl): 601S-609S.
  63. Hershkovitz A, Brill S. The association between patients' cognitive status and rehabilitation outcome in a geriatric day hospital. *Disabil Rehabil* 2007; 29: 333-337.
  64. Portegijs E, Kallinen M, Rantanen T, et al. Effects of resistance training on lower-extremity impairments in older people with hip fracture. *Arch Phys Med Rehabil* 2008; 89: 1667-1674.
  65. Mathey MF, Vanneste VG, de Graaf C, de Groot LC, van Staveren WA. Health effect of improved meal ambiance in a Dutch nursing home: a 1-year intervention study. *Prev Med* 2001; 32: 416-423.
  66. Bernstein MA, Tucker KL, Ryan ND, et al. Higher dietary variety is associated with better nutritional status in frail elderly people. *J Am Diet Assoc* 2002; 102: 1096-1104.