Bone Health, Fragility and Fractures

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Abstract

Achieving and maintaining skeletal health throughout the life trajectory is essential for the prevention of bone diseases such as rickets, osteomalacia and osteoporosis. Rickets and osteomalacia are usually a result of calcium and/or vitamin D deficiency, causing softening of bones and bone pain, and both conditions are treatable with calcium and vitamin D supplementation. Osteoporosis is a multifaceted disease mainly affecting older people, and its pathogenesis (and hence treatment) is more complex. Untreated osteoporosis results in fragility fractures causing morbidity and increased mortality.

Nutrition is one of many factors that influence bone mass and risk of bone disease. Developing a nutritional sciences approach is a feasible option for improving bone health.

The importance of adequate calcium and vitamin D in ensuring skeletal integrity throughout the life course has a sound evidence base. Poor vitamin D status in population groups of all ages is widespread across many countries (including affluent and non-affluent areas). Public health approaches are required to correct

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this given the fact that vitamin D is not just required for musculoskeletal health but also for other health outcomes.

Dietary protein may be beneficial for bone due to its effect of increasing insulin-like growth-factor-1 (IGF-1). Recent meta-analyses show that dietary protein has a beneficial role to play in bone health at all ages.

Other nutritional factors and nutrients (such as potassium, magnesium, vitamin K and acid-base balance) are also likely to have an important role in bone health, though the literature is less clear in terms of the association/relationship and more research is required.

Keywords

Bone health · Osteoporosis · Fragility fractures · Frailty · Vitamin D

Learning Outcomes
By the end of this chapter, you will be able to:

- Explain the role of key nutrients and other factors that influence bone mass and risk of bone disease.
- Apply knowledge learned and tools to identify older adults with or at risk of musculoskeletal frailty and fractures.
- Apply multicomponent strategies to prevent and manage frailty, fragility, fractures and osteoporosis.

9.1 Introduction

9.1.1 Bone

Bone is a complex living tissue. It provides structure, support and protection for the body. It is formed from collagen reinforced by minerals. There are two types of bone in the skeleton: cortical and trabecular. Cortical bone is smooth, dense and strong and is found at the surface of bone. Trabecular bone has a honeycomb structure and is found inside the bones, making bone strong, light and slightly flexible. Bone is built and develops its strength through the early years.

9.1.2 Normal Bone Metabolism

Bone metabolism is a continual cycle of bone formation and bone resorption undertaken by cells called osteoclasts and osteoblasts [1]. The bone matrix created requires mineralisation with calcium phosphate. Bone metabolism is influenced by hormones and other regulatory factors.

Think of the bones like an enormous house, constantly in need of maintenance and updating. Bone cells are like groups of workmen, ones that pull down the old walls (cells called osteoclasts) and ones that build up new walls (cells called osteoblasts). This process continues constantly, and slowly, over time, and the house (or the skeleton) is renewed. Ageing causes the groups of workmen building up new walls (the osteoblasts) to get slower and slower and fall behind their destructive colleagues. This leads to crumbling walls in the house making it more likely to fall down or the bone to fracture.

9.1.3   Peak Bone Mass (PBM)

The skeleton usually reaches maximum growth between the late second and early third decades and mineralises during this time as well. During this time, bone is being laid down faster than it is being absorbed, gradually increasing in density. Peak bone mass is achieved in the early fourth decade when bone is at its most robust. Genetic factors play a key role in the population variation of PBM, with estimates around 70–75% [2]. However, this still leaves plenty of room for key modifiable exogenous factors such as the effects of diet (including calcium, vitamin D, protein and other essential minerals) hormones and physical activity. After the fourth decade, bone mass declines, more gradually in men than women as a result of the menopause [3, 4].

9.2   Nutrients and Bone Health

9.2.1   Calcium

Calcium is an important component of the skeleton and is one of the predominant minerals found in bone. Over 99% of the body's total calcium is found in bones and teeth in the form of hydroxyapatite. The remaining 1% of calcium circulates in the blood. Phosphorus and magnesium also make up a large percentage of the bone matrix, with over 88% and 60% of the body's content of these minerals deposited in bone. There is no functional marker for calcium nutritional status, since serum/plasma calcium levels are homeostatically controlled by the body [5].

Inadequate calcium intake is a worldwide problem, having been reported in children, adolescents and adults across Europe, North America, Asia and Oceania [6]. In older adults, calcium intake varies between countries [6]. In the UK, preschool children [7] and adolescents aged 11–18 years [8] have been reported to have dietary calcium intakes below the relative UK Department of Health reference nutrient intake (RNI), whereas younger and older adults are meeting the UK RNI [8, 9].

The evidence that calcium supplementation improves attainment of bone density in childhood and prevents fractures in older age is weak and inconsistent [10, 11]. Thus, calcium supplementation is not recommended for fracture prevention at a population level.

There is however good data to show that calcium supplements are effective in reducing bone loss in late menopausal women (>5 years postmenopause), particularly in those with low habitual calcium intake (<400 mg/day) [12]. In the key study by [13], late postmenopausal women were found to have a significant reduction in lumbar spine and femoral neck bone loss following supplementation with 500 mg calcium per day, but no such effect was seen in early postmenopausal women (<5 years postmenopause). Reviews of over 20 studies have shown that calcium supplementation can decrease bone loss by approximately 1% per year. There are some data to suggest that the effect of calcium supplementation may be greater at skeletal sites with more cortical bone. There are also data to suggest that calcium supplementation improves the efficacy of antiresorptive therapy on bone mass [14].

9.2.2   Vitamin D

Vitamin D is the generic term for two molecules: ergocalciferol and cholecalciferol. Ergocalciferol (vitamin D_2) is derived by ultraviolet (UV) irradiation of ergosterol, which is found in fungi and plants [15]. Cholecalciferol (vitamin D_3) is formed from the effect of UV irradiation on the skin. The action of sunlight on the skin converts 7-dehydrocholesterol to previtamin D, which is metabolised to vitamin D by a temperature-dependent isomerisation. Vitamin D is then transported via the general circulation to the liver, where the enzyme 25-hydroxylase converts it to 25-hydroxy-vitamin D (25-OHD). This is the key circulating vitamin D metabolite and the best indicator of clinical status [15]. The kidney is the site for further conversion to calcitriol or $1,25(OH)_2D_3$.

Calcitriol ($1,25(OH)_2D_3$), the active form of vitamin D, helps to maintain normal blood levels of calcium and phosphate. It promotes calcium absorption and bone mineralisation. It also enhances osteoclastic activity (bone turnover). Together with parathyroid hormone (PTH), it regulates calcium and phosphorus metabolism by promoting calcium absorption from the gut and kidney tubules [15].

25-Hydroxy-vitamin D (25-OHD) is the major circulating vitamin D metabolite and can be measured in the blood, considered the gold standard method for establishing vitamin D status [16]. However, there is a lack of consensus and definition regarding the suggested thresholds of 25-OHD used to define vitamin D deficiency or optimal levels, and the range of terminology and associated values used make comparisons of reported prevalence difficult.

The World Health Organization and the UK's Scientific Advisory Committee on Nutrition (SACN) state that 25-OHD levels <25 nmol/L (10 mg/mL) is the deficiency threshold [17–19] with regard to the prevention of rickets and osteomalacia, and the WHO also defines vitamin D insufficiency as 25-OHD levels <50 nmol/L. However, the US Institute of Medicine (IOM) defines 25-OHD levels <30 nmol/L as deficiency, 30–50 nmol/L as inadequacy and >50 nmol/L as sufficient [20].

The UK National Osteoporosis Society has agreed with the IOM thresholds and proposed that the UK practitioners should also adopt these [21]. Commonly,

vitamin D deficiency is defined by a 25-OHD threshold of <25–30 nmol/L, with insufficiency defined by 25-OHD levels in the range of 25–49 nmol/L [22]. Conversely, the Endocrine Society Task Force (USA/Canada) define deficiency as 25-OHD levels <50 nmol/L and advocate that 25-OHD levels should exceed 75 nmol/L [23].

> Vitamin D deficiency has been associated with skeletal conditions and other musculoskeletal health outcomes. Low 25-OHD levels of <12 nmol/L in children often result in rickets [19]. In adults, 25-OHD levels ≤20 nmol/L result in osteomalacia [19].

In addition, epidemiological studies and randomised controlled trials have reported associations between vitamin D levels and muscle strength and function [24, 25], fracture risk [26, 27] and risk of falls [28]. Specifically, supplementation with vitamin D has been shown to have a positive effect on bone mineral density [26, 27, 29] with a recent meta-analysis of 23 studies showing a small benefit on femoral neck bone mineral density [30].

Our main source of vitamin D is the ultraviolet (UV) in sunlight. Much of the UV in sunlight is absorbed by clouds, ozone and other forms of atmospheric pollution. UV sunlight varies daily, seasonally and depending on latitude. In the UK, there is no UV radiation of the appropriate wavelength (280–310 mm) from the end of October to the end of March. For the remaining months of the year, the main percentage of the effective UV radiation occurs between 11.00 am and 3.00 pm [31].

A number of factors reduce the vitamin D production from UV exposure. Sunscreens absorb UVB radiation when applied to the skin, thereby reducing the production of previtamin D3. Glass absorbs all UVB photons, and hence sunlight that has passed through glass will not promote vitamin D3 synthesis in the skin. Clothing also absorbs UVB radiation; this is particularly relevant for women who cover up for cultural reasons.

There are few dietary sources of vitamin D. The major providers are fat spreads (which are often fortified with vitamin D), fish, eggs, pastry products, fortified breakfast cereals and meat [18].

9.2.3 Vitamin K

Vitamin K ('koagulation vitamin') was first described in Denmark by Dam (1935) as a dietary-derived coagulation factor [32]. He noted that a bleeding disorder in chickens was corrected by feeding a variety of vitamin K-rich foods. The fat-soluble vitamin was finally isolated in 1939. Vitamin K refers to a family of compounds with a common chemical structure, 2-methyl-1,4-naphthoquinone. Phylloquinone (vitamin K1) is present in plant-based foods, particularly green leafy vegetables.

Menaquinones (vitamin K2) are derived from bacterial fermentation of foods such as cheese [33].

Vitamin K has an important function for the skeleton. There are data to show that low serum concentrations of vitamin K are associated with low bone mineral density and increased risk for osteoporotic fracture [34].

The results of randomised controlled trials looking at the effects of vitamin K supplementation and markers of bone health have been very disappointing, and the most recent vitamin K/fracture prevention meta-analysis did not demonstrate a beneficial effect of this nutrient on markers of bone health or prevention of osteoporotic fracture [35].

9.2.4   Protein

Historically there has been much debate as to whether dietary protein is good or bad for bone health. Insulin-like growth factor-1 (IGF-1) is a hormone which builds up the bone. IGF-1 is stimulated by dietary protein intake. In terms of epidemiology, many studies have found a positive association between dietary protein intake and bone health [36, 37], but some have found no association [38]. In particular there is conflicting evidence as to whether protein intake is associated with hip fracture risk, with a recent systematic reviews and meta-analyses finding a positive association between dietary protein intake and bone mass density, but not fracture risk [39, 40]. Therefore, dietary protein may have beneficial effects on bone density, but this may not necessarily translate into reduced risk of fracture.

9.2.5   Other Nutrients

There are numerous studies looking at other nutrients including potassium, vitamin C, vitamin E and vitamin A. It is difficult to draw clear conclusions from the evidence available, and none of these supplements are routinely recommended in promoting bone health [41].

9.3   Other Factors Influencing Bone Health

Hormones are extremely important in bone health. Normal testosterone and normal menstruation are required in order for bone to reach peak bone mass. Cigarette smoking and excessive alcohol intake may further accelerate the loss of bone in both women and men [1].

The skeleton also needs to be used appropriately. Bone density is achieved by putting weight through it. Over 100 years ago, a German scientist called Julius Wolff suggested the theory that bone would adapt to the load under which it is placed and would remodel to become stronger to resist that sort of loading, now known as Wolff's law [42]. More recently, this concept has been refined to a general theory of bone mass regulation, known as the mechanostat model [43]. In the

absence of weight-bearing exercise, bone loss will occur at both axial and appendicular skeletal sites. Early astronauts discovered that when they landed back on Earth, they had lost significant bone density and strength; it is the action of gravity through bones that gives them strength.

9.4   Osteoporosis

Osteoporosis is a term derived from osteo (bone) and porous (full of holes). This means that the bone is fragile and at increased risk of fracture. There are a pathological definition based on the appearance of bone under the microscope and a clinical definition where fracture type, mechanism of fracture and results of a bone density scan are used to define osteoporosis.

Osteoporosis is often diagnosed following a low trauma fracture typically affecting the wrist, a vertebral body in the spine or a hip (more specifically the neck of femur).

The most common and widely available bone density scan is the DEXA or dual-energy X-ray absorptiometry scan [44]. The result is described by a *T*-score and a *Z*-score. The *T*-score compares the result with that of a healthy 40-year-old. The *Z*-score compares the result to an age-matched average. The *T*-score is more widely used to diagnose osteoporosis. This score has been validated for use in different populations across the world. The measurements are ranked on a scale of normal distribution. Standard deviations of +1 or −1 are considered normal. This encompasses about 80% of the population. Scores from −1 to −2.5 are considered osteopenia ('thin' bone). A *T*-score of less than −2.5 is considered as osteoporotic. There are other ways to measure bone density including quantitative CT [45], but this is much less widely used.

Bone density is a strong predictor of fracture, yet many fragility fractures occur without osteoporosis as assessed by density criteria; this highlights the need to consider additional factors other than bone mineral density that may contribute to an older adult's risk of fracture [46].

9.4.1   Risk Factors for Osteoporosis

There are a range of conditions and factors that accelerate bone density decline. These are termed risk factors and may be used in diagnosing and directing management of osteoporosis.

Osteoporosis increases with age and is more common in women, largely because of menopause and the loss of the hormonal access. Premature menopause and treatments that bring on menopause or reduce testosterone increase risk. Amenorrhoea associated with multiple pregnancies or often seen in eating disorders is strongly associated with reduced bone density [46, 47].

Osteoporosis is more common in Caucasian or Asian individuals and in those with a family history of maternal or paternal hip fracture. Body mass index is important with osteoporosis being more common in those who are underweight due to

Table 9.1 Risk factors for fractures [46, 49]

Nutritional status	Deficiencies calcium, vitamin D, magnesium, protein. Low body weight
Lifestyle	Smoking, alcohol (>2 units/day), physical inactivity, lack of nutritious food
Falls	Previous falls
Skeleton 'diseases'	Family history of osteoporosis or fractures. History of low-impact fracture. Thoracic kyphosis, height loss (>4 cm), low BMD
Endocrine diseases	Type 2 diabetes, hyperthyroidism, hyperparathyroidism, Cushing's disease
Inflammatory diseases	Rheumatoid arthritis, connective tissue diseases, spondylitis, IBD
Respiratory diseases	Asthma, COPD
Neurological/ psychiatric diseases	Parkinson, multiple sclerosis, stroke, depression, dementia
Immune diseases/ cancer	HIV
Medications	Proton pump inhibitors, affecting gonadal hormone production. Some immunosuppressants, antidiabetic drugs, antipsychotics, anticonvulsants Excess thyroid hormone treatment

less basal bone mass and those with obesity. Both smoking and alcohol increase risk in a dose-dependent fashion [48].

Secondary osteoporosis occurs in those with other conditions associated with osteoporosis, e.g. rheumatoid arthritis, type 1 diabetes, untreated long-standing hyperthyroidism, hypogonadism or premature menopause (less than 45 years), chronic malnutrition (including eating disorders such as anorexia nervosa) or mal-absorption, chronic liver disease and osteogenesis imperfecta in adults (Table 9.1) [50].

Medications associated with osteoporosis include steroids, low molecular weight heparin, proton pump inhibitors (e.g. omeprazole, lansoprazole), SSRIs (selective serotonin reuptake inhibitors; antidepressants), aromatase inhibitors for breast cancer and anti-epileptics. This list is by no means exhaustive. These are often dose-dependent, with longer exposure being more highly correlated with risk. In the context of steroids, a significant proportion of bone loss is thought to occur in the first 3 months of treatment. A clinically relevant dose is more than 3 months of at least 5 mg of prednisolone daily (Table 9.1) (Chap. 19) [51].

9.5 Fragility, Fractures and Falls

Fragility is defined as 'the quality of being easily broken or damaged' [52]. A fracture is a crack or break in a bone. Fragility fractures occur as a result of a fall from a standing height in someone with delicate or vulnerable bones. Fragility fractures are common and occur in one in three women and one in five men aged over 50 years. It is estimated that across the world a fragility fracture occurs every 3 s.

Falls are more common with age and one third of people over 65 years of age will fall each year. Falls are more likely to result in fractures, particularly in those

with osteoporosis. A previous fracture is a strong predictor of future fractures [53]. This is often progressive with time; Fig. 9.1 highlights the progressive impact of osteoporosis, as commonly seen in ageing individuals.

Wrist fractures often occur in early stages of osteoporosis in mobile individuals who fall forwards onto an outstretched hand. They usually result in a temporary disability but heal well with most individuals regaining most of their previous level of function. Vertebral fragility fractures may occur insidiously without significant trauma and be attributed to an exacerbation of chronic back pain. Progressive vertebral fractures can occur over many years resulting in loss of height with significant curvature of the spine (kyphosis) leading to progressive problems with balance, mobility and breathing. Hip fractures are considered the most significant fragility fracture associated with increased morbidity and mortality. They usually occur in older adults with intracapsular fractures resulting from a sideways fall onto the hip. There has been a focus on hip fracture management in the UK over the last 12 years with year-on-year reduction in mortality with the latest figure of 6.1% at 30 days [55]. However the 1-year mortality remains around 22% [56].

A significant proportion of older adults presenting with hip fracture have frailty. One study identified that 17% had no frailty, 39% had mild frailty [4, 5] and 44% had moderate to severe frailty [57]. Frailty is a widely used term in healthcare and is associated with functional decline and mortality. It is often associated with multimorbidity and ageing but is not synonymous with either. The word frailty often conjures up an image of an older person such as that described above, with poor muscle mass, a curved spine and arthritic joints struggling with mobility and function [58, 59].
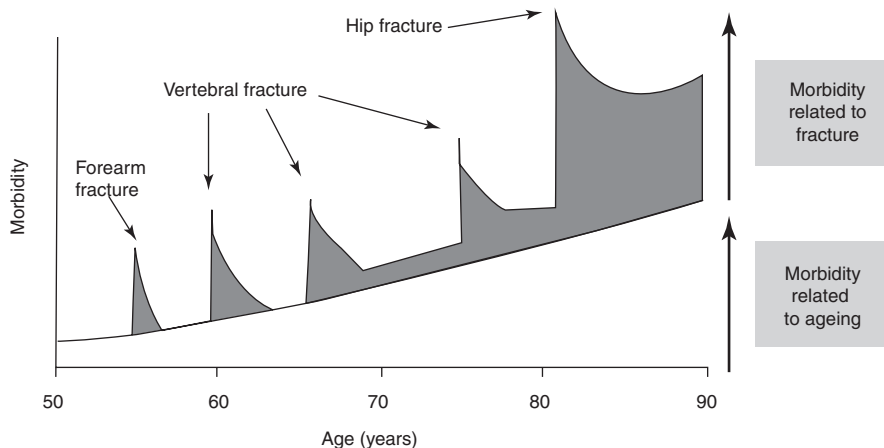
Adapted from Journal of Endo Investigation, 1999, Kanis JA and Johnell O

Fig. 9.1 The burden of osteoporosis [54]. (With permission of Kanis JA, Johnell O. The burden of osteoporosis. J Endocrinol Invest. 1999;22(8):583–8)

Key causes of frailty, prevalence, associated outcomes and preventative and interventional management strategies have been previously detailed (Chap. 8). We highlight here the concept of musculoskeletal frailty, which often includes a loss of muscle (sarcopenia), loss of collagen (osteoarthritis) and loss of bone (osteoporosis) [60]. All elements of musculoskeletal frailty can be significantly reduced by a life-course approach to healthy ageing [61] (Chaps. 4 and 14). This is important as musculoskeletal frailty is a key predictor of fall-related fractures.

9.5.1 Frailty, Falls and Bone Health Assessment

9.5.1.1 Frailty Assessment
The description of frailty using a phenotypical approach was first described by Fried [58] and colleagues requiring the presence of three or more out of five indicators: weakness (reduced grip strength), slowness (gait speed), weight loss, low physical activity and exhaustion. Whilst global consensus is lacking, a useful broad definition encompasses a loss of physiological reserve so that systems fail with minor stressors. Frailty can be classified in many ways; a practical and widely used tool for frailty identification is the Rockwood Clinical Frailty Scale. This scale can be applied for those with frailty as a result of physical or cognitive decline (Fig. 9.2) [62].

9.5.1.2 Falls Risk Assessment
In addition to advancing musculoskeletal frailty, other key factors influencing the incidence of falls include effects of polypharmacy, metabolic imbalances, cardiac events, related to alcohol intake, lack of a safe living environment, visual disturbances, reduced cognition (with poor safety awareness) and also reduced continence resulting in hurrying to the toilet or trying to manage incontinence [63]. A recent study has identified that malnourished inpatients were almost 8 times more likely to have a harmful fall than those not malnourished, independent of age and BMI [64].

Consequently, clinical care guidelines, for example, the UK's NICE Guideline [65], recommend that older people are asked about their history of falls whenever coming into contact with health or social care practitioners. Where falls (or risk of falls) have been identified, older adults should be offered a multifactorial risk assessment and interventions to prevent further falls.

9.5.1.3 Bone Health Assessment
Given the complexities within and across sarcopenia, osteoarthritis, osteoporosis and frailty and the diversity of factors that contribute to fracture risk, bone health assessment requires an individualised, comprehensive approach. In a number of settings, bone health assessment applies a personalised fracture risk assessment tool such as FRAX® (https://www.sheffield.ac.uk/FRAX/). The FRAX® tool uses clinical risk factors to establish an individual's fracture risk based on studying population-based cohorts from Europe, North America, Asia and Australia.
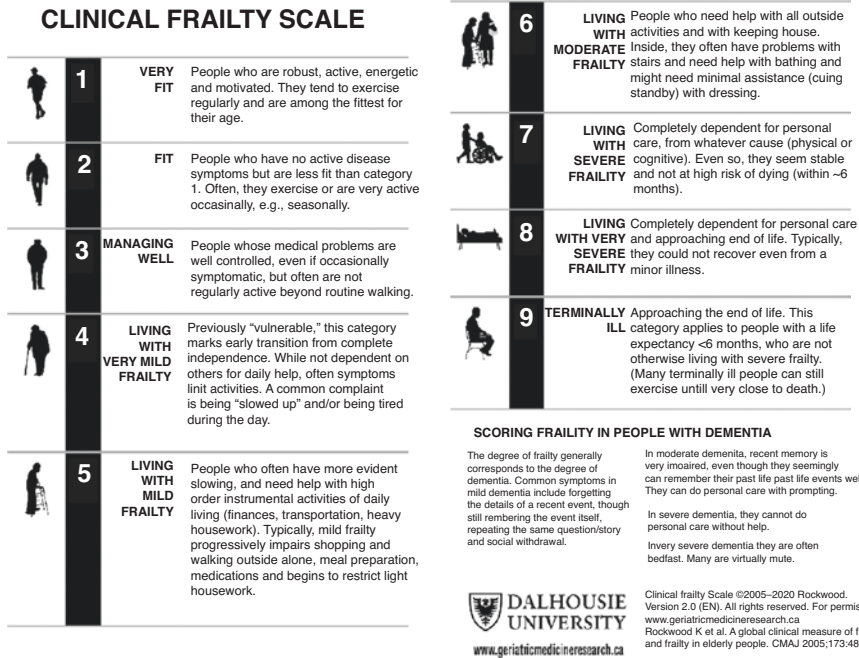
CLINICAL FRAILTY SCALE

	1	**VERY FIT**	People who are robust, active, energetic and motivated. They tend to exercise regularly and are among the fittest for their age.
	2	**FIT**	People who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasinally, e.g., seasonally.
	3	**MANAGING WELL**	People whose medical problems are well controlled, even if occasionally symptomatic, but often are not regularly active beyond routine walking.
	4	**LIVING WITH VERY MILD FRAILTY**	Previously "vulnerable," this category marks early transition from complete independence. While not dependent on others for daily help, often symptoms linit activities. A common complaint is being "slowed up" and/or being tired during the day.
	5	**LIVING WITH MILD FRAILTY**	People who often have more evident slowing, and need help with high order instrumental activities of daily living (finances, transportation, heavy housework). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation, medications and begins to restrict light housework.
	6	**LIVING WITH MODERATE FRAILTY**	People who need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance (cuing standby) with dressing.
	7	**LIVING WITH SEVERE FRAILTY**	Completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~6 months).
	8	**LIVING WITH VERY SEVERE FRAILTY**	Completely dependent for personal care and approaching end of life. Typically, they could not recover even from a minor illness.
	9	**TERMINALLY ILL**	Approaching the end of life. This category applies to people with a life expectancy <6 months, who are not otherwise living with severe frailty. (Many terminally ill people can still exercise untill very close to death.)

SCORING FRAILTY IN PEOPLE WITH DEMENTIA

The degree of frailty generally corresponds to the degree of dementia. Common symptoms in mild dementia include forgetting the details of a recent event, though still rembering the event itself, repeating the same question/story and social withdrawal.

In moderate dementia, recent memory is very imoaired, even though they seemingly can remember their past life past life events well. They can do personal care with prompting.

In severe dementia, they cannot do personal care without help.

Invery severe dementia they are often bedfast. Many are virtually mute.

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Fig. 9.2 The Rockwood Clinical Frailty Scale. *Source*: (Canadian Study on Health & Aging, Revised 2008. 2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489–495. © 2007–2009. Version 1.2. All rights reserved. Geriatric Medicine Research, Dalhousie University, Halifax, Canada. Permission granted to copy for research and educational purposes only. Participating Sites: Cape Breton District HEALTH AUTHORITY Making Healthier Choices Together Sponsors: © 2007–2009. Version 1.2. All rights reserved. Geriatric Medicine Research, Dalhousie University, Halifax, Canada. Permission granted to copy for research and educational purposes only)

The FRAX® algorithms are freely available on the website and give the 10-year probability of fracture. The National Osteoporosis Guideline Group graphs provide a visual guide for clinicians and patients in recommending treatment, further assessment with DXA scan or lifestyle advice.

An initial fragility fracture is a strong predictor of second fracture; the importance of secondary fracture prevention cannot be overemphasised. As an example, Hip Fracture Care Clinical Care Standards require that hip fracture patients are assessed for future fall and fracture risk by suitably qualified orthogeriatric healthcare professionals, with documented plans for management including assessment for risk of falls, fall history and risk factors for falls, including a medication review, and formulation of a plan to prevent further falls. Despite such recommendations, falls risk assessment and secondary prevention strategies such as prescription of bone protection medication are often not undertaken following identification of initial fragility fracture. Audit data continues to highlight substantial variation and an

ongoing, significant care gap that appears resistant to improvement and, consequently, missed opportunities to prevent consequent fractures [66].

9.6   Supporting Those with Frailty, Fragility, Fractures and Osteoporosis

Despite clearly articulated risk factors at the population level, for many individuals a fall and subsequent fracture is usually a significant and unexpected event. It can lead to a loss of confidence, isolation, reduced physical function, disability and in some cases a reliance on informal/formal care or even a change in living circumstances. Falls and fractures often also lead to a new diagnosis of osteoporosis, a disease which the older adult may have hitherto been unaware of. Individuals need access to the right treatment, support, education and encouragement to enable them to make the best possible recovery and to prevent further fractures occurring.

9.6.1   Lifestyle Advice to Improve Bone Health

Lifestyle advice includes nutritional guidance including sources of calcium, vitamin D and other essential nutrients and minerals as described above. Ceasing smoking, avoiding alcohol excess and encouraging a balanced diet rich in fruit and vegetables and ensuring at least sufficient or increased protein intakes (as recommended in older adults) may also contribute to the prevention of osteoporosis, improved bone health and/or reduced complications [1, 53, 67, 68].

For older adults with conditions that affect nutrition, a dietitian review is advised. Suggesting exercise as a prescription rather than a casual activity can influence uptake (Chap. 14). It is important to support the older adult through the initial trauma recovery to the post-injury rehabilitation and ultimately to a regular exercise schedule to maintain their mobility and balance.

Physical activity and exercise plays [1] a key role in improving bone health as well as improving balance. The work carried out by the Royal Osteoporosis Society (ROS) in the recent 'strong, steady and straight campaign' is a helpful consensus document providing the evidence to encourage older adults to exercise and provides the healthcare provider some clarity around the use of exercise in those with osteoporosis [69]. Strategies to reduce the risk of falls are also recommended as a key lifestyle management approach [49].

Older adults with osteoporosis often experience loss of confidence following a low-impact fall resulting in fracture. Thus their fear of falling results in restriction of movement and lifestyle. This in turn results in deconditioning and an increase in their risk of further falls and fracture. This consensus document indicates that increased activity and weight-bearing exercise is likely to provide greater lifestyle benefits and reduce fracture risk.

9.6.2   Supplementation and Medications

For most patients, calcium and vitamin D supplements are recommended. Medication for established osteoporosis has a good evidence base, for example, antiresorptive therapy (e.g. bisphosphonates, denosumab). Hormonal treatments may also be appropriate for some individuals [1]. Consideration must be given to potential side effects and adverse outcomes, duration of treatments and monitoring processes for prescribed supplements and/or medications [12].

Long-term medication adherence however remains a challenge [70] with less than 30% of patients continuing to take medication at 2 years. The asymptomatic nature of osteoporosis requires careful attention to emphasise the risk of complications from untreated disease. There are many factors which affect patients' persistence [71].

These can be positively influenced by establishing a good relationship with the older adult, a medication regime to suit the individual and a clear understanding of the benefits. Negative influencers include the effect of negative press reports on long-term use of antiresorptive agents. As an example, the SCOOP trial in 2012 [72] identified that patients who underwent a DEXA scan and had the result explained to them were more likely to be adherent and persistent with medication.

Whether in relation to supplements or medications likely to adversely influence bone health and fracture risk, older adults should be supported to make an informed decision regarding medication by providing clear information about benefits and possible side effects. It is essential for older adults also to understand how to take medications to ensure they are effective and to minimise potential harm [49].

9.6.3   Education, Training and Sociopolitical Action

Valuable research by Yardley et al. [73] into designing and delivering advice about falls prevention indicated that if falls prevention education is given in a patronising way, where the individual is somehow seen to be negligent or they have done something 'stupid', they are less likely to engage in a falls prevention programme.

Listening to the older adult's experience of falling and placing falls education within an exercise/balance initiative can make the older person more likely to actively engage in both falls prevention and exercise [63, 73].

Training to support the management of osteoporosis should be integrated into training processes across medical, nursing and allied health disciplines [49]. Programme and political level action is the recognised fourth pillar for orthogeriatric care; advocating for change in healthcare policy and priorities by engaging and mobilising healthcare leaders, policymakers and other sociopolitical influencers is a key factor to realising better bone health for individuals and populations [49, 72, 74].

Across acute, rehabilitation and secondary prevention settings, the importance of education and training for older adults, their carers, healthcare providers and services, organisations and professional bodies should be considered a fundamental priority. This is perhaps best highlighted by the Fragility Fracture Network call to action [75] which highlights the need for engaged, educated healthcare stakeholders to support coordinated care for those with or at risk of fragility fracture across acute, rehabilitation and secondary prevention settings. Perhaps most importantly, this needs to be underpinned sociopolitical action to overcome the failure for uptake of key opportunities for care improvement.

9.6.3.1 Coordinated Care Opportunities to Optimise Bone Health, Fragility and Fractures in Older Adults

Example 1: Orthogeriatric Services
Orthogeriatric services have been developed as a result of a focus on hip fracture care. Best practice for hip fractures involves early surgery and standardised perioperative management with coordination between orthopaedic, anaesthetic and geriatric services [76].

A coordinated approach throughout the older adult's journey is imperative to ensure that individuals are optimised before surgery to reduce post-operative complications and have access to appropriate interdisciplinary rehabilitation. Falls and bone health assessment are key to future fracture prevention.

Care Example 2: Fracture Liaison Services
The 'Capture the Fracture' campaign led by the International Osteoporosis Foundation is a global resource supporting the implementation of a post-fracture coordination programme such as a fracture liaison service. This coordinated, multidisciplinary approach has a strong evidence base in preventing further fractures also resulting in significant cost saving for healthcare systems and has also been demonstrated to reduce mortality [55, 77]. Globally there are almost 600 fracture liaison services registered with the 'Capture the Fracture' campaign over 48 countries (https://www.capturethefracture.org/).

Example 3: Fracture Liaison Nurses
Advancing older adult understanding through education is the key to self-management of bone health. The approach must be adjusted to the individual, their abilities and experience. For older adults living with frailty, engagement with their family and carers is often required. In many settings, fracture liaison nurse (FLN) roles have been established to advance knowledge of falls and bone health in addition to skills in health promotion. The overarching roles of the FLN (or similar positions) often include supporting an individual in coming to terms with their injury, working through the stages of the illness experience, encouraging older adults to actively participate in rehabilitation and educating older adults to manage their own bone health [78].

Example 4: Audit and Feedback

The role of audit and feedback to improve outcomes is well established. Implementation of the National Hip Fracture Database in the UK has been associated with improvements in care and survival of older people with hip fracture [79]. As a further example, the Fracture Liaison Service Database (FLS-DB) is a UK continuous audit, initiated to measure performance against standards of management of secondary prevention of fragility fractures set primarily by the National Institute for Clinical Excellence (NICE) and the Royal Osteoporosis Society. In 2017 there were 65 fracture liaison services operational in the UK who contributed data to the FLS-DB (https://www.fffap.org.uk/). Whilst the 2020 report demonstrates improvement in most key performance indicators, the audit highlights further opportunities to advance effective and efficient services.

9.6.3.2 End-of-Life Care

Lifestyle interventions, supplements and education to improve/maintain bone health are imperative to reducing population incidence of frailty, falls and fragility fractures. However, for those with severe frailty (CFS > 7) or end-stage disease, priorities are likely to be different and may require a refocus towards managing symptoms and comfort rather than disease prevention or cure (Chap. 21).

9.7   Summary

For all those working with older adults, it is important to have some insight into the complex interrelationship between bone health, fragility and fractures. Nutrition plays a key role in the promotion of bone health in the older population. The role of calcium and vitamin D is well established and dietary supplementation may be required. Less is known about the effects of dietary protein, acid-base balance and micronutrients.

Prevention of musculoskeletal frailty through a life-course approach focusing on a healthy diet, regular exercise and multi-component management of osteoporosis is recommended. Older adult and healthcare provider education is key to adherence to treatment strategies following fragility fractures; orthogeriatric services, fracture liaison services, fracture liaison nurses and feedback and audit processes should be considered a healthcare system priority.

Regardless of the age or stage of disease, individualised attention towards benefits versus burdens of potential interventions should be considered and where appropriate discussed with the older adult to guide patient-centred care. Actions to prevent initial disease onset and preventable complications must become the priority. Conversely, focus for management at the end of life is likely to be comfort, as at this stage it is unlikely that nutritional supplements, exercise or medication for bone health will be beneficial.

Take-Home Points

- Nutrition plays a key role in the promotion of bone health in the older population.
- There is a complex interrelationship between bone health, fragility and fractures.
- Orthogeriatric services, fracture liaison services, fracture liaison nurses and feedback and audit processes should be routinely embedded in practice.
- Engaging older adults, their carers, healthcare providers, organisations and professional bodies to prioritise a multi-component, life-course approach to preventing and managing bone health, fragility and fractures.

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