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Perspective Article

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Risk factors and prevention of osteoporosis-related fractures

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Abstract

In order to effectively prevent osteoporosis-related fractures, one must aim to prevent both osteoporosis, as well as the events and circumstances that may lead to injury, ultimately resulting in fracture. Among all the osteoporotic fractures that can occur, hip fractures are associated with a severe decrease in quality of life and high mortality, which reaches 51% at one year post-fracture in nonagenarians. Prevention of osteoporosis should ideally begin in childhood, aiming to achieve high peak bone mass accompanied by an inherently healthy lifestyle throughout life, in order to minimize bone loss during middle and third age, and in parallel to avoid or diminish other fracture risk factors. There are numerous fracture risk factors, including age, gender, race, lifestyle and concomitant medical conditions, which either cannot or can be modified, to a greater or lesser degree. Falls consist a previously underestimated risk factor, responsible for a large percentage of fractures. International and national strategies aimed at public awareness, early identification of those at increased risk for fracture and preventive or therapeutic intervention may succeed in subduing the currently increasing prevalence of osteoporotic fractures.

Keywords: Osteoporosis, Prevention, Fractures, Falls

Introduction: the socioeconomic magnitude of the problem of osteoporosis-related fractures

Osteoporosis is a multifactorial skeletal disease, characterized by a reduction in bone mass and deterioration of the microarchitectural structure of bone tissue, with a resulting increase of bone fragility and of fracture risk[1]. Osteoporosis is one of the major causes of disability, morbidity and mortality in older people[2]. It is a current worldwide socioeconomic problem with an increasing severity and frequency, due to the progressive aging of the world's population. It has been estimated that the total medical care costs for osteoporosis in Europe, including hospitalization and rehabilitation, were 36.3 billion euros in 2000, and that the corresponding projected costs in 2050 will be 76.8 billion euros, i.e., more than double[3,4]. Worldwide projections estimate that the number of hip fractures by 2050 could range between 7.3 and 21.3 million, with a corresponding cost of 100 billion euros[5]. Given these estimates, it seems imperative that international and national strategies aiming to prevent and reduce osteoporotic fracture incidence will have to be effectively implemented worldwide.

Fractures of the hip, spine and forearm have long been regarded as the classical sites of osteoporotic fractures; however, almost all types of fractures are increased in individuals with compromised bone quantity and quality[2,6]. Clinically, fragility fractures may be defined as fractures that occur as a result of minimal trauma, such as a fall from a standing height or less, or after no identifiable trauma at all. The lifetime risk at 50 years of age for any osteoporotic fracture ranges between 40-50% in women and 13-22% in men, which is considered very high[6].

Two main goals have to be fulfilled in order to prevent osteoporosis-related fractures: the occurrence of events that lead to high-energy or low-energy injury must be prevented and the severity of osteoporosis has to be diminished.

Fractures secondary to injury

High-energy injury from sports or traffic accidents occur more frequently in young male and middle-aged individuals. Senior citizens have been reported to be especially vulnerable to both high-energy injury from traffic accidents as vehi-

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cle occupants[7] and pedestrians[8], as well as to low-energy injury, such as falling from standing or sitting, or lifting light objects, which may result in a fracture if bone strength is compromised[9,10]. Both types of injuries may necessitate hospitalization or even lead to death. Mortality rates of the elderly (65+) from motor vehicle traffic accidents in the EU countries ranged from a low of 6.5 persons/100,000 population in the UK, to a high of 28.2 persons/100,000 population in Greece, in 2002. In comparison, mortality rates of the elderly (65+) due to falls in the EU countries during the same period ranged from a low of 14.4/100,000 population in Greece, to a high of 164.5/100,000 population in Hungary, indicating more than double mortality rates from falls[11].

Regarding low-energy injury in the elderly, approximately 1 in 10 falls results in a serious injury, such as head injury, soft tissue injury or fracture. Overall, the main risk factors for fractures include the hazard of falling and osteoporosis. Among the fractures that may occur, hip fractures in particular consist a major socioeconomic problem, and one of the most important causes of morbidity and mortality. Especially in the elderly, they are extremely debilitating, lead to loss of confidence, confinement, a generally reduced quality of life, and are associated with high hospitalization and rehabilitation costs. One year mortality following a hip fracture may range from 16% in people 60 years of age, up to 51% in nonagenarians[12,13]. Hip fracture incidence varies worldwide and is influenced by numerous risk factors, discussed below.

Fall facts

Approximately 90-95% of hip fractures are caused by falls[2,10,14]. However, not all falls are equally likely to cause a hip fracture. Only about 1% of falls in elderly women result in a hip fracture[2]. The likelihood of fracture is affected, apart from bone quality and quantity, also by the energy of the fall and the point of impact being on or near the hip[15]. Falls in elderly people usually occur with small velocity, landing on their hip, with increased risk of hip fracture. On the other hand, middle-aged people, who move around with higher velocity, often fall on their arms, having increased risk of fracture of the humerus or distal forearm[16]. Approximately 75% of proximal humerus fractures and 95% of distal forearm fractures are the consequence of a fall. Interestingly, only approximately 25% of vertebral fractures are the consequence of a fall, indicating that decreased vertebral bone mass and compression fractures are responsible for the remaining percentage; these fractures usually occur during domestic activities because of intense action of the abdominal and spinal muscles.

Fractures due to osteoporosis – risk factors

There are many risk factors for osteoporotic fractures, such as age, gender, race, geographical region, diet, lifestyle, hormonal status, bone density, bone quality, body mass index and medical comorbidities, which can broadly be grouped into the main categories presented below. Some of them cannot be modified, due to their intrinsic nature; others, however, can be prevented or influenced, anticipating a desired decrease in fracture incidence.

Age

For any bone mineral density measurement, fracture risk is much higher in the elderly than in the young[17]. The frequency of hip fractures in particular increases exponentially with age, especially after the age of 70, in both men and women, in most regions of the world[2,18]. This increase in fracture risk is considered to be due to both the age-related decrease in bone mineral density of the proximal femur and the age-related increase in falls, and is also related to the increased comorbidities of the elderly.

Hormonal factors – gender differences

Women attain a lower peak bone mass compared to men. The increased bone loss in women after menopause and their increased propensity to falls compared to men, eventuates that the incidence of hip fractures in women of any age in the USA and Europe is about twice that of men at any age. In addition, because women live longer than men, more than 75% of all hip fractures are presented in women. Most researchers report a 2:1 ratio of female:male hip fracture incidence over the age of 65[2,16,19,20]; however, regional variations exist.

Other hormonal factors that increase fracture risk are premature menopause, primary or secondary amenorrhea (as from female athlete triad or *anorexia nervosa*), hyperthyroidism, hyperadrenocorticism, and primary and secondary hypogonadism in men.

Demographic factors

Several studies have shown that variations in fracture incidence exist, depending on demographic factors, such as geographical region and race. Variation has been documented internationally[21,22], as well as intranationally[16,23]. In general, northern countries appear to have an increased incidence compared to southern ones[21,23,24]. Fracture incidence has been reported to be higher in white Scandinavian women than in North American women of comparable age[2]. The lifetime risk of any osteoporotic fracture at the age of 50 years has been estimated to be 46% in women and 22% in men in Sweden, with corresponding figures of 40% and 13% in the USA[6]. In addition, the lifetime risk and the age-specific risk of a hip fracture among black men and women is approximately 50% of that among white men and women[20]. In India, osteoporotic fractures have a higher male to female ratio than among Westerners[25].

Lifestyle risk factors

It is important for all persons to be accustomed to a "healthy" balanced diet and a physically active lifestyle beginning from childhood and continuing throughout life, for nor-

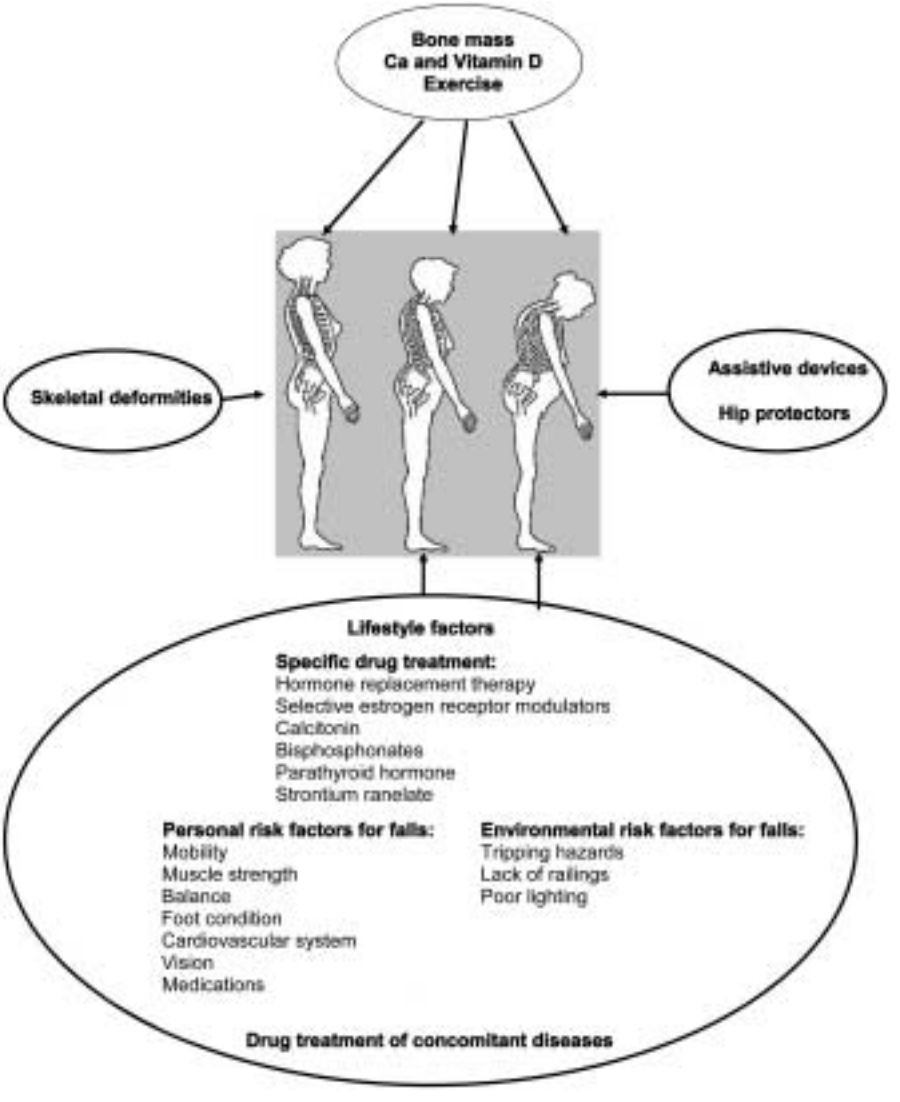

Figure 1. Factors to be considered for the prevention of osteoporosis-related fractures throughout life.

mal skeletal growth and aging[26,27]. Adequate calcium intake has been demonstrated to be significant for increasing and maintaining bone mass. The importance of vitamin D for the intestinal absorption of calcium is also well documented. Hence, inactivity or immobilisation, low dietary calcium intake, vitamin D deficiency, as well as cigarette smoking, caffeine intake, excessive alcohol consumption, and liability to falls, consist lifestyle risk factors for osteoporotic fractures[2,28].

Medical history

Fracture risk factors include a previous fragility fracture, family history of fracture or genetic factors, low bone mineral density, low body mass index, weight loss, resting pulse rate over 80 beats per minute, rheumatoid arthritis, use of corticosteroids, anticonvulsants, loop diuretics, and liability to falls (e.g., due to neuromuscular, cardiovascular and vestibular disorders, poor vision, dementia, use of certain drugs and polypharmacy)[20,29,30].

Prevention of osteoporosis-related fractures and falls

Prevention of osteoporosis should begin early in life (Figure 1). Primary prevention during growth and adolescence should aim at attainment of a high peak bone mass, adequate calcium intake, exercise, and early diagnosis and treatment of potential skeletal deformities[26,27]. Secondary prevention during middle-age aims at identifying the population with low bone mass and more than one risk factor for an osteoporotic fracture and entering upon pharmacological and lifestyle multifactorial interventions. Pharmacological interventions include calcium,

vitamin D, hormone replacement therapy, selective estrogen receptor modulators, calcitonin, bisphosphonates, parathyroid hormone and strontium ranelate. Some of the preventive measures for osteoporosis have also been demonstrated to be effective for the prevention of falls, such as adequate calcium and vitamin D intake and exercise[31]. Various kinds of exercise, particularly load-bearing exercises, induce an increase in bone mineral density and may indirectly protect individuals from fractures by improving mobility, muscle strength and balance, thereby reducing the risk of falls[32]. Tertiary prevention in the elderly aims at dealing with high-risk individuals, those with established osteoporosis or post-fracture treatment. Apart from pharmacological treatment, it aims to ensure intestinal absorption of calcium is improved and vitamin D levels are adequate[33]. Risk factors for falls should be examined and dealt with, as fall incidence is age-related: about 30% of persons of 65 years of age fall each year, reaching 50% of those 80 years or older[14,31,34].

Personal risk factors for falls to be assessed include previous falls, lack of physical activity, muscle weakness, gait and balance problems, neuromuscular diseases, disability of the lower extremities, inadequate footwear, functional limitations regarding activities of daily living, proprioceptive impairment, dizziness, fainting or loss of consciousness, cardiovascular conditions (such as arrhythmia, hypertension or syncope), visual problems, urinary incontinence, cognitive impairment and certain medications (such as antidepressants, sedatives, antiarrhythmic and antihypertensive agents)[28,35]. Multifactorial risk assessments by geriatricians or physicians, followed by interventions targeting the identified risk factors, can be successful in preventing falls[35]. Mobility problems can be improved by tailored exercise interventions with progressive muscle strength, gait and balance training. Management, or if possible, treatment of the underlying cause, is recommended for concomitant chronic diseases. Review of the medications administered currently should be carried out so as to ascertain their necessity and benefits, while their side effects or interactions are minimal. Efforts should be made to reduce the total number of medications to four or less, which has been shown to reduce the risk of falling[35].

Environmental fall risk factors to be assessed include obstacles or other tripping hazards, lack of stair railings or bath mats and bars, and insufficient lighting. Safety assessment of the living environment and appropriate modification should be conducted both for persons living independently in the community and for residents of nursing homes. Assistive devices and hip protectors also play an important role in reducing falls and hip fractures[36]. Naturally, the persons at risk, as well as their family or carers, should be well-informed regarding the benefits of prevention strategies regarding both personal and environmental risk factors, for them to comply, and for all the above approaches to have a beneficial effect. Ideally, if national health systems worldwide include early bone quality screening and therapy, as well as fall risk assessment and intervention programs in their insurance policies, then fracture incidence in the increasing aging population may decline.

Conclusion

Osteoporosis-related fractures consist a multifactorial and increasing public health worldwide issue. Prevention strategies should ideally focus on all the different life phases of skeletal growth, bone maintenance and loss. If effective, they may improve the quality of life of the affected individuals, lengthen life-span and decrease healthcare costs. Wealthy countries with high fracture risk may be able to reduce fractures by aggressive implementation of programs to assess and treat high risk individuals, especially as regards to bone quality and liability to falls, thereby achieving fracture prevention. Countries with limited medical resources and lower fracture risk may have to follow guidelines that are selective about screening and administering preventive and therapeutic programs, according to their cost-effective policies.

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