

Enhancing Bone Health in Aging Populations to Prevent Fragility Fractures

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The prevalence of fragility fractures is immense and projected to escalate in the upcoming decades due to shifting demographics. Fragility fracture is extremely prevalent in older adults and is known to have a staggering cost of treatment (1). As the population ages, the number of fracture incidents will increase, placing a significant burden on healthcare systems, society, and patients. Fragility fractures are fractures that occur from any mechanical forces in low energy of trauma (2). The most common locations are the vertebrae, hip, and wrist. A fragility fracture implies the diagnosis of osteoporosis. Osteoporosis is classified by primary osteoporosis and secondary osteoporosis (3). Primary osteoporosis occurs due to disturbances of sexual hormones, aging, or both. On the other hand, secondary osteoporosis is mostly caused by chronic diseases and certain types of drugs, such as corticosteroids (3). Menopausal osteoporosis is one of the examples of primary osteoporosis, which occurs frequently and becomes the most common health-related problem among women (4).

Osteoporosis is the most common disorder amongst the elderly, resulting in a low bone mass as well as the microarchitecture deterioration of the bone tissue, leading to increased bone fragility and prominently increasing the risk of fracture (5). According to the World Health Organisation (WHO) (2004) (6), the classification of osteoporosis in postmenopausal women is based on the Bone Mineral Density (BMD) T - score ≤ -2.5 of the young adult mean. Whereas osteopenia or low bone density is defined as a BMD T - score between -1.0 SD and -2.5 SD. Fragility fractures commonly occur in these two different conditions, namely osteopenia and

osteoporosis. Any patient with a fragility fracture (regardless of T- score) is defined as having osteoporosis (6). Surgical management of lower extremity fragility fractures is expensive, with a significant cost differential between high-income and low-income countries (1). Addressing osteoporosis and its associated fractures is pivotal for improving global health outcomes. Understanding the definition of osteoporosis, predicting fracture risks, stratifying the likelihood of fractures, setting intervention thresholds, and identifying appropriate interventions are key clinical considerations (7). The dynamic nature of bones undergoes intricate transformations as individuals age. This process is underscored by diminished bone density, notably evident in postmenopausal women due to hormonal shifts, though a universal decline in bone mineral density affects both genders. Such alterations elevate vulnerability to fractures, warranting a keen focus on proactive interventions (7).

Factors Influencing Bone Health

Nutrition and bone integrity

The fundamental integrity of bones relies significantly upon essential minerals, notably calcium, which serve as a cornerstone for bone strength. The incorporation of a diet abundant in diverse sources of calcium, complemented by sufficient intake of vitamin D, assumes a pivotal role in facilitating the processes of bone mineralisation and density augmentation (8).

The role of calcium as a critical mineral in bolstering skeletal structure has been extensively documented. Its presence within the skeletal matrix accounts for the rigidity and

structural resilience of bones, thereby contributing substantially to overall bone strength. Furthermore, the supplementation of calcium through dietary means has demonstrated pronounced effects on bone health, primarily by fortifying bone mineral density and mitigating the risk of bone-related disorders such as osteoporosis (9).

However, the efficacy of calcium in fostering optimal bone health is intricately interlinked with the availability and assimilation of vitamin D. Vitamin D orchestrates the absorption and utilization of calcium within the body, thereby facilitating its incorporation into bone tissue (10). Inadequacies in vitamin D levels may impede the optimal utilization of calcium, potentially compromising bone mineralisation processes and overall bone density. The synergy between a well-balanced diet inclusive of diverse calcium sources and adequate vitamin D intake serves as a cornerstone in fortifying bone integrity (9). Understanding and implementing dietary strategies that encompass these essential nutrients are imperative for sustaining optimal bone health and mitigating the risks associated with compromised bone density and strength.

Physical activity and musculoskeletal health

The relationship between physical activity and musculoskeletal health is profound, particularly concerning the impact of tailored exercises on bone health and fracture prevention (11). Tailored exercise routines, comprising weight-bearing activities and resistance training, play a pivotal role in fostering optimal bone health by eliciting a dual effect of stimulating bone formation and preserving bone mass.

Weight-bearing activities and resistance training exert mechanical loads on bones, stimulating osteoblastic activity and consequent bone formation. This stimulation induces a positive adaptation within the skeletal structure, enhancing bone density and strength. Furthermore, these exercises contribute significantly to the maintenance of bone mass, thereby potentially reducing the susceptibility to bone-related disorders, such as osteoporosis (12).

Additionally, the incorporation of balance-enhancing exercises within physical activity routines assumes critical importance in musculoskeletal health (13). These exercises serve as a preventive measure against falls, mitigating the risk of fractures, particularly in vulnerable populations such as the elderly. By improving proprioception and neuromuscular coordination, balance-focused exercises contribute substantially to fall prevention strategies, consequently reducing the incidence of fractures (14).

Ultimately, the role of tailored exercises, encompassing weight-bearing activities, resistance training, and balance-enhancing routines, holds paramount significance in promoting musculoskeletal health. These exercises not only stimulate bone formation and preserve bone mass but also serve as a crucial strategy in curtailing fall-related fracture occurrences (14). Understanding and incorporating such tailored exercise regimens are pivotal in enhancing overall musculoskeletal integrity and reducing the burden of bone-related complications.

Lifestyle behaviour

The significance of optimising musculoskeletal health is underscored by the imperative need to address lifestyle behavior that detrimental habits, notably smoking and excessive alcohol consumption (15). Smoking, as a habit, exerts deleterious effects on bone healing processes and vascular function, while excessive alcohol intake detrimentally impacts bone density and structural integrity.

Smoking, is recognised for its multifaceted adverse health implications, specifically hampers bone healing mechanisms and vascular function (16). The presence of toxic compounds in cigarettes disrupts osteogenic processes, thereby impeding bone regeneration and prolonging healing periods in cases of fractures or bone injuries. Moreover, the vasoconstrictive effects of smoking compromise adequate blood flow to bones, further impeding their healing capacity and compromising overall bone health (17).

Similarly, excessive alcohol consumption is implicated in the compromise of bone density and integrity (18). Prolonged and excessive

alcohol intake disrupts bone remodeling processes, leading to decreased bone mineral density and increased susceptibility to fractures. Alcohol interferes with osteoblast and osteoclast function, impairing the delicate balance between bone formation and resorption, consequently compromising bone strength and structural integrity.

The imperative to address detrimental lifestyle habits, particularly smoking and excessive alcohol consumption, arises from their profound impact on musculoskeletal health. These habits not only impede bone healing mechanisms and vascular function but also significantly undermine bone density and integrity. Awareness and intervention targeting these lifestyle behaviors are crucial in mitigating their adverse effects and preserving optimal musculoskeletal function and structure.

Fracture risk assessment and preventive measures

Assessment of fracture risk suggested to identify certain clinical risk factors such as Bone Mineral Density (BMD), FRAX (Fracture Risks Assessment) tools, family history of hip fracture, low body weight, cigarette smoking, excessive alcohol consumption, corticosteroids therapy, low dietary calcium intake, vitamin D deficiency, rheumatoid arthritis, premature menopause, primary or secondary amenorrhoea, primary and secondary hypogonadism in men, Asian or Caucasian race, poor visual acuity, neuromuscular disorders, and prolonged immobilisation (19). The preventive measures should be addressed holistically, considering individual health conditions and lifestyle factors. This preventive measure plays a crucial role in reducing the incidence of fragility fractures and promoting overall bone health.

1) Clinical factors: Assessing clinical indicators such as age, gender, and medical history forms the foundation of fracture risk evaluation. Advanced age, particularly in postmenopausal women, predisposes individuals to decreased bone density and increased fracture susceptibility due to hormonal changes and bone remodelling alterations. Concurrent medical conditions, including osteoporosis, rheumatoid arthritis, or

endocrine disorders, further elevate fracture risks (20).

2) Bone health parameters: Bone mineral density assessments, conducted via dual-energy X-ray absorptiometry (DXA) scans, aid in quantifying bone strength and identifying osteoporosis-related fracture risks (21). Additionally, evaluating bone quality, microarchitecture, and turnover rates contributes to a comprehensive understanding of fracture susceptibility beyond bone mineral density alone.

3) FRAX tools: The FRAX tools used mainly to identify the risk for getting fractures especially in elderly. As an example, WHO FRAX tool 10-year calculation for probability fracture aims to calculate the 10-year probability fracture of a patient with osteoporosis. The calculation is based on age, sex, height, weight, previous fracture, parent with hip fracture, smoking status, presence of rheumatoid arthritis, secondary osteoporosis, alcohol consumption, and femoral neck BMD (22). Another vital component of FRAX assessment is fall prevention assessment that aiming to identifying patient's risk of falling. Assessment of a patient's risk of falling can be performed using a fall-risk assessment tool. Some suggested tools are Morse Fall Scale (MFS), St Thomas Risk Assessment Tool in Falling Elderly Inpatients (STRATIFY), and Heindrich II Fall Risk Model (HFRM). Assessment of intrinsic and extrinsic factors of fall, such as focus on balance and gait with the used of Time Up and Go (TUG) assessment, Fall Free Prevention Questionnaire (FFPQ) and Fear Falling Activities - Specific Balance Confidence (ABC) Scale (23). All the assessment tools are valuable for screening as an early detection of risk for fractures because prior incidents of fractures serve as crucial predictive factors for future fracture risks (24). Individuals with a higher risk of getting fracture and have history of fragility fractures demonstrate an increased likelihood of subsequent fractures, signifying the importance of early intervention and preventive measures.

4) Lifestyle, home safety measures and environmental factors: Lifestyle choices significantly impact fracture risks. Sedentary habits, low calcium and vitamin D intake, smoking, and excessive alcohol consumption

weaken bone structure and elevate fracture susceptibility. Environmental factors encompassing home hazards, inadequate lighting, and lack of assistive devices further augment the likelihood of falls and resultant fractures (25), especially in elderly populations. The implementation of home safety measures through environmental modifications and the integration of safety interventions stands as a pivotal strategy in mitigating the risk of falls and consequent fractures among vulnerable populations (25). Environmental modifications encompass a range of measures aimed at minimizing hazards within the home environment. This includes the removal of potential obstacles or tripping hazards, ensuring adequate lighting, and optimizing furniture arrangements to create unobstructed pathways. By mitigating environmental risks, these modifications serve to reduce the likelihood of falls, particularly in individuals susceptible to balance impairments or mobility limitations. Simultaneously, the installation of assistive devices constitutes a proactive approach in enhancing home safety. Installing grab bars in bathrooms, handrails along staircases, and non-slip mats in high-risk areas such as bathrooms and kitchens significantly augments stability and minimizes the risk of falls. These assistive devices play a crucial role in providing additional support and reducing the probability of accidents, thereby mitigating the incidence of fractures resulting from falls. All preventive measures serve to create a safer living environment, effectively reducing the occurrence of falls and the subsequent detrimental impact on musculoskeletal health.

5) Medication and behavioural factors: Certain medications, notably glucocorticoids and long-term use of specific drugs, pose a risk by compromising bone density or increasing fall propensity (20). Moreover, behavioural aspects such as impaired vision, mobility limitations such as stability and imbalance gait, and cognitive decline contribute substantially to fracture risks by elevating the likelihood of falls.

The comprehensive assessment of fracture risk factors and preventive measures involves an interdisciplinary approach, integrating clinical, physiological, behavioural, and environmental considerations. Identifying and quantifying these multifaceted determinants not only aids in risk stratification but also informs targeted

interventions aimed at mitigating fracture risks and preserving musculoskeletal health.

Enhancing bone health among aging populations requires a comprehensive approach. By focusing on nutrition, physical activity, lifestyle modifications, home safety, regular medical assessments, identifying fracture risk factors and, when needed, advanced interventions, individuals can significantly reduce the risk of fragility fractures. This proactive stance not only promotes independence but also contributes to a higher quality of life as individuals age.

Article History:

Submitted: 11 November 2023

Accepted: 20 November 2023

Published: 30 November 2023

DOI: 10.31436/ijcs.v6i3.342

ISSN: 2600-898X

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