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Application of Nutritional, Pharmacological and Physical Therapy Interventions in Delaying Degenerative Changes: Systematic Review

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Abstract

This study investigates the influence of Latin-origin words in the Kazakh and English languages, focusing on terms related to "experience" and "problems." The research analyzes the etymology, modern usage, and challenges arising from the incorporation of these terms into Kazakh, a non-Latin script language. The study highlights the role of Latin-derived vocabulary in modern scientific, technological, and academic discourse, and the unique linguistic and cultural challenges it presents in Kazakh. A comparative analysis of the Kazakh and English terms for "experience" and "problems" is provided, emphasizing the nuances of meaning, connotation, and cultural differences in their use. The study also discusses the tension between modernization and linguistic purity in Kazakh, considering the impact of globalization on native language development. The relevance of this research lies in the growing significance of Latin-derived terminology in non-Latin script languages, particularly in the context of globalization. The study explores how Latin-origin words are both shaped by and reshape the cultural and linguistic landscape in Kazakh and English, contributing to the ongoing discourse on language standardization, bilingual education, and cultural preservation in the face of globalization. The findings underscore the complex interplay of language, culture, and global interconnectedness, presenting implications for future linguistic policy and language planning, especially within multilingual societies..

Keywords: *Osteoporosis, Ageing population, Degenerative Changes, Nutritional Interventions, Pharmacological Interventions, Bone and Joint Health and Physical Therapy Interventions.*

Introduction

Osteoporosis is among the major non-communicable diseases affecting mostly individuals above 50 years of age. Globally, 200 million women are affected due to osteoporosis (International Osteoporosis Foundation, n.d.). Osteoporosis is a metabolic bone disease where there is an imbalance at the cellular level (Föger-Samwald et al., 2020). It is mainly caused due to increased osteoclastic bone resorption without adequate osteoblastic bone formation, thereby, leading to weakened, fragile bones and heightened fracture risk. Ageing populations worldwide face heightened susceptibility to fractures due to declining bone mass, often leading to immobility, chronic pain, and a heightened risk of mortality, especially following hip fractures (Ahire et al., 2024).

Additionally, current studies also state that the changes in the gut microbiota also contribute to osteoporosis (Ahire et al., 2024). This implies that osteoporosis is primarily caused due to changes in metabolism as an individual ages. Thus, ageing populations worldwide face heightened susceptibility to fractures due to declining bone mass.

Currently, osteoporosis is diagnosed through X-ray. At the same time, the pharmacological treatments include bisphosphonates. However, these pharmacological interventions address only part of the spectrum of degenerative changes characteristic of senile osteoporosis and are confined to inhibiting reabsorption in bones (Khosla & Hofbauer, 2017). In contrast, anabolic effects have been effectively maintained for years. This suggests a need to involve an integrative approach that not only slows down bone loss but also generalizes overall musculoskeletal health and function. Apart from this, nutritionally, proper levels of calcium, vitamin D, and protein intake are essential. Studies depicts that the adequate amount of vitamin D

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and calcium intake can almost reduce fracture risks and enhance BMD in the elderly (Hejazi et al., 2020). Strict nutrition management is anticipated to ensure better Bone Mineral Density.

Research study found that specific physical exercises can manage osteoporosis (Zhang et al., 2022). This type of physical training is also effective in reversing the effects of osteoporosis with time. Exercises such as weight-bearing and resistance strengthening strengthen bones, posture, and ambulation through the application of mechanical forces on the bones. However, they do not enhance bone strength or reverse the disease. On the basis of such understanding, it can be assumed that integrated approach with physical therapy, nutritional management, and pharmacological treatment can be beneficial in osteoporosis management. With this objective in mind, the present study focuses on the possibility of nutritional, pharmacological, and physical therapy interventions in the light of delaying degenerative changes in senile osteoporosis. To better explore the research, the objective is divided into the following research question:

RO1: Do nutrition interventions modify the course of joint and bone density loss in elderly patients with senile osteoporosis?

R02: What are the effects of pharmacological therapy on degenerative changes of bone and joint in elderly patients with osteoporosis?

RO3: What are the effects of physical therapy interventions on on the health of bone and joints among the elderly with osteoporosis?

RO4: Whether Multimodal interventions would show potential synergistic benefits in the managements of senile osteoporosis to prevent fractures or joint degeneration?

The need for a multimodal approach in the management of senile osteoporosis is significant. Moreover, by supporting an effective reduction in the number of fractures and dependency on high-tech care, multimodal strategies will further alleviate the economic and caregiving burdens of osteoporosis. Thus, it will delay or even prevents degenerative changes in the bones associated with aging, thereby, allowing older adults to achieve greater independence and quality of life.

Literature Review

Joint Degeneration and Bone Density Loss in Senile Osteoporosis

Senile osteoporosis is a characteristic natural decline of bone density and joint health with age. Senile osteoporosis arises from physiological changes such as cellular aging, hormonal alterations, and changes in bone metabolism (Qadir et al., 2020). In this terms, senile osteoporosis is different from postmenopausal osteoporosis. While secondary osteoporosis is primarily caused among postmenopausal females due to a deficiency in estrogen, senile osteoporosis is derived from the physiological changes such as hormonal alteration, cellular ageing, and bone metabolism modifications (Hawkins et al., 2021). This condition triggers frailty and increases the chances of fractures of bones like the femur and spine, which primarily withstand loads. Consequently, in senile osteoporosis, loss of the function of osteoblast with increased osteoclastic activity results in irregularities in bone remodelling and decreased BMD.

Furthermore, joint degeneration, including changes in both the articular cartilage and synovium, is frequently accompanied by senile osteoporosis. It causes increase in the morbidity among elderly people. Pignolo et al. (2021) have outlined the burden imposed on the aging adults stating that Osteoporosis causes a structural weakening of bones and joint degeneration. the burden imposed on the aging adults. The most daunting aspect of the damage is hip fractures, which are associated with high mortality and expensive health care costs due to long recovery requirements. However, the structural weakness of bones combined with degeneration of a joint impose an enormous burden on both patients and health care services. Management of this complex condition, therefore, requires more holistic therapeutic strategies.

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Effect of Nutritional Intervention on Osteoporosis

Recent studies have included that nutritional intervention can control osteoporosis. A review on existing studies established that calcium and vitamin D supplementation decreases the risk of fracture among elderly populations, therefore indicating their effectiveness in the management of osteoporosis (Chen et al., 2019). This aligns with another study which stated that Calcium, vitamin D, protein, and anti-inflammatory ingredients are potentially important in prevention and treatment of osteoporosis (Guo et al., 2023). The researchers concluded that calcium is essential to the structural strength of the bone matrix, whereas vitamin D favors calcium absorption, which directly relates to bone mineral density. Additionally, Rondanelli et al. (2021) demonstrated that these nutrients relate directly to the better improvement in the bone density of those over 65. Based on these insights, the basis of the nature of empirical studies to be identified in this study originated. Thus, nutritional interventions influence the deterioration rate of the joints and bone density among the older generation of senile osteoporosis patients in old age.

Effect of Pharmacological Interventions on Osteoporosis

Currently, pharmacological intervention is the most common approach taken for osteoporosis. Elahmer et al. (2024) presented the therapeutic strategies and insights on the pharmacological interventions. Bisphosphonates, such as alendronate, reduce bone resorption by inhibiting osteoclast activity. Similarly, SERMs, including raloxifene, mimic estrogen's protective effects on bones, reducing spinal fractures but offering limited impact on hip fractures. However, they can lead to side effects like gastrointestinal issues and, rarely, osteonecrosis of the jaw. On the other hand, Denosumab, a RANK ligand inhibitor, represents a newer approach, inhibiting osteoclast activity to prevent bone loss (Barnsley et al., 2021). However, like other medications, denosumab may lead to a rebound effect in bone loss if discontinued. Nonetheless, the insights imply the effects of pharmacological treatments degenerative changes in bone and joint health in elderly individuals with osteoporosis.

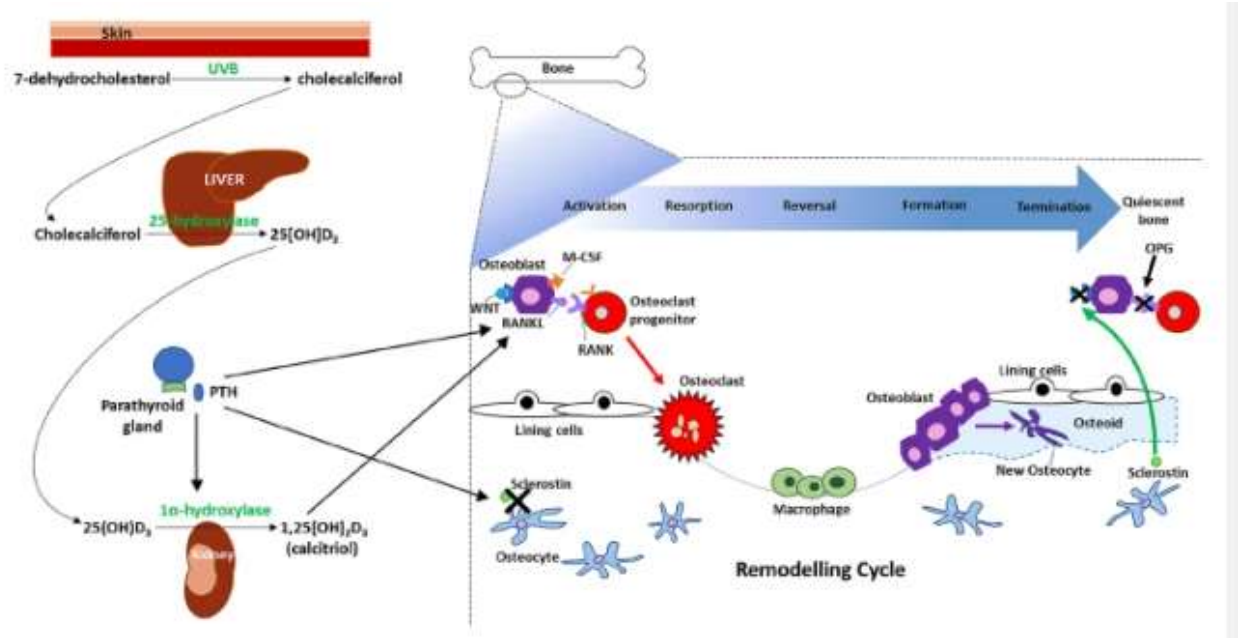

Figure 1. The activity of the RANK ligand inhibitor adapted from Barnsley et al. (2021) shows

Research Gap

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Despite recent progress in the management of osteoporosis, much of its heterogeneity in aged populations remains untreated with wide gaps. Most of these interventions appear to focus on bone loss in terms of density, thus ignoring the systemic causes and lifestyle drivers associated with this particular condition known as osteoporosis. While oxidative stress and inflammation are established contributors to bone ageing, more research would be necessary to understand how specific dietary and lifestyle modification might restrain these effects. a comprehensive, multimodal approach may provide an effective and sustainable alternative for managing senile osteoporosis. Therefore, this study aimed at probing the possibilities of nutritional, pharmacological, and physical therapy interventions in delaying degenerative changes in senile osteoporosis.

Theoretical Framework

The investigation of the potential way of delaying senile osteoporosis through nutritional, pharmacological, and physical therapy is based on theoretical frameworks. Considering physiological, psychological, and environmental factors, the theories included in this study are mechanotransduction theory, biopsychosocial model, and the oxidative stress theory of ageing. Mechanotransduction theory explains the conversion of mechanical forces to biochemical signals, influencing bone remodeling (Yavropoulou & Yovos, 2016). This focuses on weight-bearing and resistance exercises in the management of osteoporosis because they stimulate bone forming and improve strength in muscles, thereby reducing the risk for falls. Additionally, the oxidative stress theory of aging postulates that the cumulative damage from free radicals pushes the process of cellular aging and degenerative conditions like osteoporosis (Ghezzi et al., 2017). Finally, the biopsychosocial model basically draws attention to an interaction among biological, psychological, and social considerations that affect health results. The theories supports the role of anti-inflammatory diets and antioxidant supplements in holistic efforts to slow bone degeneration among the aging. Thus, these models in medical treatment and diet therapy should be supplemented by psychological support and social rehabilitation in the management of patient senile osteoporosis.

Methodology

Research Design

This research took on a systematic review of nutritional, pharmacological, and physical therapy interventions for potential of delaying senile osteoporosis. This research type is best synthesized with the systematic review study design, as it gathers and evaluates evidence from specific focused questions of research (Siddaway et al., 2019). In this context, the outcome may be different from place to place, depending on health and practice contexts related to an individualized type or injury (Cowell, 2015). Thereby, the approach is widely relevant in the geratology medicine environment. Thereby, a systematic review allows to aggregate, assess, and analyze all existing literature to observe patterns or gaps or make recommendations for practice and future research. This is especially useful in osteoporosis research because studies conducted on small samples, or using different methodologies, prevent a cohesive body of evidence from emerging. The study utilises PRISMA to ensure methodological rigour and transparency in systematic reviews (Figure 1). Thus, this study would aid in addressing the gap in literature, by assessing the potential of Delaying Degenerative Changes.

Search Strategy

The study followed a robust search strategy. Literature was searched on databases, namely, PubMed, Cochrane Library and Scopus. Additionally, specific keywords were utilised for the search (Table 1). The keywords were applied with Boolean operators such as, AND, OR and NOT. Boolean operators did not limit the search rather expanded it broadly while keeping data toward identified studies only.

Table 1. Search Keywords

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Keywords	
RQ1	Nutritional interventions AND osteoporosis Calcium AND osteoporosis Vitamin D supplementation AND bone health Antioxidants AND bone health Protein intake AND osteoporosis Dietary interventions AND osteoporosis Micronutrients AND bone density Anti-inflammatory diet AND osteoporosis Nutritional deficiency AND osteoporosis
RQ2	Pharmacological interventions AND osteoporosis Osteoporosis medications Bisphosphonates AND osteoporosis Denosumab AND bone density SERMs (Selective Estrogen Receptor Modulators) AND osteoporosis RANK ligand inhibitors AND osteoporosis Drug therapy AND senile osteoporosis
RQ3	Physical therapy AND osteoporosis Weight-bearing exercise AND osteoporosis Resistance training AND bone health Exercise interventions AND osteoporosis Mechanotransduction AND bone health Fall prevention AND elderly Functional mobility AND osteoporosis
RQ4	Functional independence AND osteoporosis Quality of life AND osteoporosis Fall risk AND elderly

Additionally, reports and conference proceedings were also looked into. Furthermore, the study also followed a strict exclusion and inclusion strategy. The inclusion strategy included:

- Literature only between 2014-2024 and in the English language
- Peer-reviewed literature
- Randomized controlled trials (RCTs), cohort studies, and case studies.

On the other hand, review articles, opinions and editorials were excluded. Similarly, studies not focusing on overuse injuries were also excluded. This way, it was ensured that the study was relevant to the research aim and minimised bias. Thus, 30 articles were identified for the study forward.

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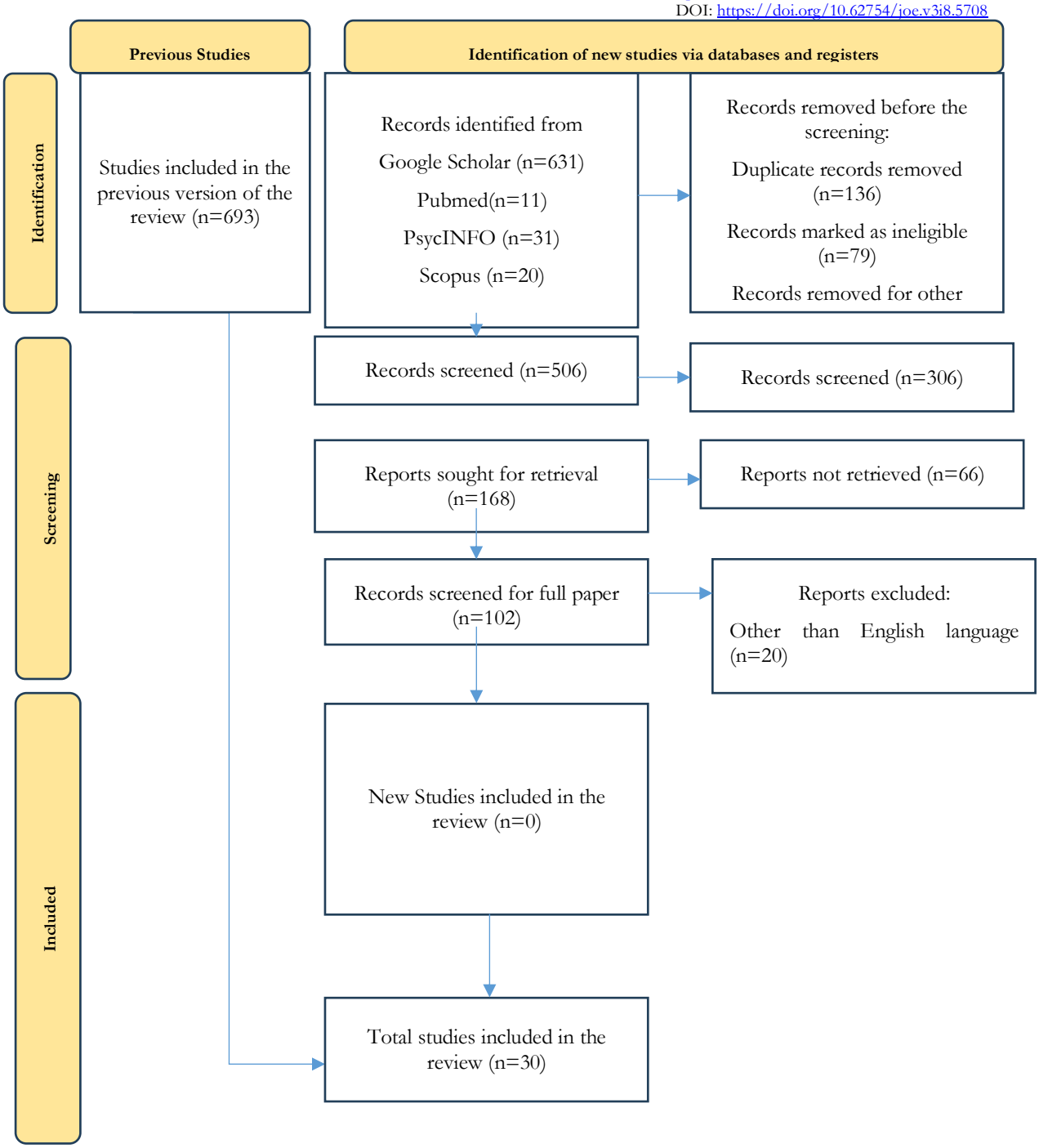

Figure 2. PRISMA flowchart to identify relevant studies.

Data Extraction and Appraisal

The data extraction process followed a standardized approach. Study quality was then evaluated using the CASP for randomized controlled trials (RCTs) and the Newcastle-Ottawa Scale for cohort studies (Higgins, n.d.), Subsequently, studies rated as low, moderate, or high risk of bias based on criteria such as randomization, blinding, and selection bias. Key study characteristics—author, year, population, type of overuse injury, intervention, and main outcomes—were documented. These assessments provided insights into study type and quality.

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Data Analysis

The literature was analyzed using thematic analysis, an approach that supports interpretative data organization, particularly useful when study outcomes and methodologies vary (Braun & Clarke, 2012). Using repeated readings for pattern seeking, the data were coded by going back to the raw data and creating themes that particularly were relevant to the research questions, ensuring a systematic method of gathering, assessing, and analyzing data to ensure a structured methodology with reduced bias and findings would be grounded in high-quality evidence.

Findings

Following the data analysis, various themes emerged as discussed below:

Major Theme: Impact of Nutritional Interventions on Senile Osteoporosis

Nine of the thirty selected studies provided insight into the potential impact of nutrition on bone health. Subsequently, five main themes emerged:

Theme 1: Effect of Dietary Patterns on Bone Health

The importance of particular diets in preserving bone health was emphasized by this theme. Two sub-themes thus arose in light of the observed diet type and its impact.

Sub-Theme 1: Effect of Mediterranean Diet on Bone Preservation

Mediterranean Diet is among those diets gaining recognition worldwide. It can help reduce the risk of osteoporosis fractures in elderly people because of its rich nutritious anti-inflammatory and antioxidant compounds (Benetou et al., 2018). The findings of the CHANCES project indicate that a stronger adherence to the MD tends to lead to a considerable reduction in the incidence of hip fractures within aged populations. This occurs through nutrient-dense foods like fruits and vegetables, along with olive oil, that aid BMD. Similarly, finding in the analysis by Ballesteros et al. (2020), the MD had a lower fall risk, indicating that its benefits go beyond merely bone health to muscle strength and balance, which is important for fracture prevention. Though, a major limitation in the available Mediterranean diet studies is reliance on self-reported dietary intakes. Subsequently, this would introduce recall bias and regional variations in adherence to the MD that could influence outcomes across different populations. Though the benefits of MD seem largely consistent, Papageorgiou et al. (2020) noted that the acid load of the MD varies among individuals with metabolic responses, thus differently influencing bone microstructure.

Sub-theme 2: Vegetarian and Vegan Diets and its effect on Bone Density

Thorpe et al. (2021) reported that vegans, particularly postmenopausal women, face a notably higher risk of hip fractures compared to non-vegetarians. Vegetarian and vegan diets, while advantageous for lowering chronic disease risk, can present challenges for bone health. This occurs due to the lack of vitamin D and calcium. This highlights the need for targeted supplementation in plant-based diets to support bone health.

Further, Itkonen et al. (2021) indicated that replacing animal proteins with plant proteins can heighten bone turnover, increasing bone resorption. In this respect, it was noted that supplemental calcium and vitamin D can reduce the risk of fractures for vegan followers as found by Thorpe et al. (2021). Hence, the bone density loss probability is associated with minimum levels of essential nutrients. That means, without supplementation, a plant-based diet could fail to support sufficient intervention for older people's bones. Moreover, although supplements appear to yield benefit, variability in the amount and bioavailability across studies suggests that a uniform guideline on nutrient supplementation should be paramount in strategies to prevent osteoporosis through diet laid on plants.

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Theme 2: Protein Sources and Bone Turnover

The theme on protein sources highlights the role of protein intake in the diet in ensuring the health of the bone. Itkonen et al. (2021) found that increased plant protein intake for 12 weeks resulted in higher turnover markers of bones. Replacing animal proteins with plant proteins impacted bone turnover. This pointed to increased risks for deterioration of bones if animal protein is minimized without adequate supplementations of vitamin D and calcium. For instance, desalted duck egg peptides also have emerging studies that seem promising well (Guo et al., 2023). This would indicate the need for a balanced protein strategy in handling the bone issue during osteoporotic management. These peptides would activate the differentiation of osteoblast and matrix mineralization through the Wnt/β-catenin pathway. Thereby, provides them with a potential function to enhance the process of bone formation in treatment for osteoporosis.

Theme 3: Impact of Vitamin D and Calcium Supplementation

The supplementation with vitamin D has demonstrated a significant improvement in bone density particularly when supplemented in deficient individuals. Shahnazari et al. (2019), who had conducted their intervention for 8 weeks with vitamin D supplementation, reported that BMD improved in osteoporotic patients. The study further highlighted that the treated patients showed fewer markers of osteoporosis compared to the control group. Complementing this, research from the Adventist Health Study suggests that calcium and vitamin D together can effectively reduce fracture risk, especially beneficial for vegan populations with lower calcium intake due to the absence of dairy (Thorpe et al., 2021). This interaction underscores the importance of targeted supplementation in dietary patterns that may lack these key nutrients.

Theme 4: Inflammation, Gut Health, and Bone Health

One of the symptoms of osteoporosis entails inflammation. Thereby, some of the studies highlighted that proper nutrition can aid in addressing inflammation while also maintaining gut health. Subsequently, two sub-themes emerged.

Sub-theme 1: Probiotics and Inflammation Reduction

The connection between inflammation and osteoporosis is increasingly recognized. This is instrumental as chronic inflammation is shown to accelerate bone resorption. Probiotic treatments, particularly with Lactobacillus acidophilus (L.A.), have shown potential in reducing inflammation and providing osteoprotective effects. In a rat model of osteoporosis (Allam et al., 2023). Allam et al.(2023) found that L.A. decreased inflammatory markers such as the NLRP3 inflammasome and caspase-1, resulting in reduced bone resorption and preservation of bone density. This decrease in inflammatory cytokines raises the possibility that probiotics can prevent bone loss brought on by inflammation, which would be especially helpful for older people who frequently suffer from "inflammaging," which is known to contribute to bone loss.

Sub-theme 2: Effect of Gut Health on Bone Density

Probiotics contribute to gut health, now considered to be beneficial to bone health. Allam et al. (2023) highlighted that probiotic supplementation increased the bioavailability of these nutrients. Subsequently, it suggested that the gut microbiome could be a potential mediator for the management of osteoporosis through enhanced nutrient uptake. Additionally, the gut microbiota composition improved by probiotics such as Lactobacillus acidophilus (L.A.), increases the absorption of the nutrients (Allam et al., 2023). These are pivotal to the strengthening of the bones, which include calcium and magnesium. Indeed, most of the obtained results through promising preclinical studies have been established in animal models. Therefore, there is a requirement for human trials to assess the long-term outcome associated with specific probiotics on inflammation and bone health. The clinicians should further emphasize clinical trials on how probiotics may modulate inflammation and nutrient absorption in ageing populations to validate these effects. Thus, optimal strains and dosages for bone preservations also have to be standardized in the future.

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Theme 5: Effect of Moderate Alcohol on Bone

According to Fung et al., (2019), red wine may raise BMD more efficiently than other types of liquor by increasing estrogen content-a factor that is essential for maintaining the health of bones in postmenopausal women. Moderate intake of alcohol, particularly red wine, has been found to elevate the bone density, especially among postmenopausal women. Moreover, polyphenols and antioxidants of red wine, such as resveratrol, may stimulate osteoblast activity and reduce osteoclast differentiation. Consequently, it aids in reducing bone resorption and strengthening bones. However, these benefits rely on low to moderate consumption, as higher alcohol intake can have adverse effects, leading to increased bone resorption and a higher fracture risk. The relationship between alcohol and bone health is dose-dependent and varies across demographics, indicating a complex interaction. Further controlled studies are essential to confirm these findings and determine safe levels of alcohol consumption, particularly for specific population groups, to avoid promoting alcohol as a primary osteoporosis prevention strategy.

Major Theme: Impact of Pharmacological Interventions on Senile Osteoporosis

Ten of the remaining twenty-one discussed the pharmacological interventions for senile osteoporosis. Subsequently, five themes emerged according to some of the common pharmacological measures.

Theme 1: Bisphosphonates and Their Acceptability

Currently, bisphosphonates are extensively used for the treatment of osteoporosis, especially, fracture prevention. Narayanasamy et al. (2022) found that intravenous bisphosphonates are generally more accepted by patients and preferred over oral bisphosphonates. Thereby, they often suffer from low adherence due to complex dosing requirements and gastrointestinal side effects. This finding points to a need for optimized delivery methods to improve long-term outcomes for elderly patients. Additionally, Katthagen et al. (2023) reported that bisphosphonates reduce the risk of secondary fractures and surgical complications in elderly patients undergoing fracture repair. The study provided evidence for the efficacy of bisphosphonate treatment after proximal humeral fracture to prevent surgical complications. Particularly among males it aids in enhancing bone density and structural integrity. Therefore, this means that bisphosphonates would have the advantage of increasing bone density and structural strength concurrently. Hence making it even more valuable for postoperative rehabilitation in osteoporosis patients.

Another research work by Cubria et al. (2020) underlined the investigation of zoledronic acid within a Hutchinson-Gilford progeria mouse model. Therefore, this new emerging therapy greatly improved the type of bone structure, bone density, and overall integrity of the cartilage in the model. The evidence improved bone and cartilage by pharmacological intervention. These results indicate zoledronic acid having great potential for reducing bone loss and degeneration of cartilage. In the same way, Mugnier et al. (2019) experiment proved that at 30 months, the risk of refractures is reduced by up to 70%, given that consistent treatment has been offered over a period of a year or even more. This research considered the long-term efficiency of treatments meant for osteoporosis, including anti-resorptive agents such as, bisphosphonates as a strategy of reducing the risk of refracture in elderly patients. This highlights that these interventions can be utilised to treat osteoporosis alongside bone density.

Theme 2: Romosozumab and Emerging Therapies

The studies highlighted emerging pharmacological therapies and drugs that are considered for treating osteoporosis. Ishikawa et al. (2024) conducted a study using the drug romosozumab. A 3-month treatment with romosozumab significantly improved BMDs around spinal implants compared to eldecalcitol. Preclinical effects of sclerostin inhibitor romosozumab have been promising for the enhancement of bone density and structural stability, particularly in patients undergoing spinal surgeries. By enhancing volumetric BMD in areas around the implant, romosozumab offers the possibility to reduce the common complications of loose implants, junctional failure, and cage subsidence in instrumentation surgeries among patients with osteoporosis. While its efficacy in increasing BMD is undisputed, there are concerns about its long-term safety and cardiovascular risks. However, the increase in BMD and biomechanical stability

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underlines the utility of romosozumab in the perioperative management of osteoporosis, especially in populations at very high risks of failures related to implants. This study again puts forward that an individualized approach needs to be utilized to maximize surgical outcomes while carefully monitoring patient safety.

Theme 3: Inflammation Management

One of the prominent clinical characteristics of osteoporosis is inflammation. Wu et al. (2020) found that Geraniol showed promise in reducing joint inflammation by inhibiting pathways like PI3K/Akt/NF-ϰB and MAPK, both linked to OA progression and cartilage breakdown. This highlighted that anti-inflammatory agents are gaining attention for their potential in managing osteoarthritis (OA) and osteoporosis-related joint deterioration. By reducing indicators like PGE2, COX-2, and TNF-α, the method of action effectively reduced inflammation and cartilage degradation. Thereby, suggesting it may be useful for osteoporosis patients with concurrent OA.

On the other hand, Eugenol also shows cartilage-protective effects by modulating the JAK3/STAT4 signalling pathway (Wu et al., 2023). Eugenol's impact on chondrocytes in inflammatory environments highlights its potential for elderly osteoporosis patients at higher risk of joint degradation. Wu et al. (2020) found that eugenol not only reduced inflammation but also preserved cartilage matrix proteins, including type II collagen and aggrecan which is crucial for joint health. Subsequently, these pharmacological agents show good promise, however, there is a need of further clinical validation is needed. While these show potential for future address for elderly patients facing multiple degenerative conditions, there remains the impending need for managing the osteoporosis condition.

Theme 4: Zinc Supplementation

Studies also elaborated on the potential of zinc supplementation for maintaining bone health. Nakano et al. (2021)observed a notable improvement in bone mineral density (BMD) over 12 months with zinc therapy. Zinc is vital in various enzymatic processes for bone mineralization, and deficiency has been linked to weakened bone strength. Thereby, the study highlights zinc's role in fostering bone formation and reducing fracture risk among vulnerable groups. In this study, zinc supplementation increased bone formation markers without affecting resorption markers, suggesting a balanced approach to bone turnover. However, it was highlighted that excessive resorption without adequate bone formation leads to bone loss seen in osteoporosis, hence, a balance is required. These findings underscore zinc's value in both enhancing bone density and preserving bone integrity in the elderly. However, it also emphasises how important it is to take nutritional supplements in order to keep bones healthy, which supports the promise of a multimodal strategy.

Theme 5: Addressing Oxidative Stress

Lee et al. (2021) showed that Ginkgolide B highly reduces ROS, which involves the inhibition of osteoclast activity but the promotion of osteoblast function. *Ginkgo biloba* has promise in osteoporosis treatment as it can scavenge free radicals and also participate in bone remodeling. This compound has a function of controlling the level of ROS, thus may have utility in glucocorticoid-induced osteoporosis, especially among the elderly suffering from chronic inflammation. This balanced mechanism can become crucial in cases of osteoporosis with oxidative stress in maintaining the density of bones. The balance of oxidative stress will do something about loss factors of bone and stress factors that significantly contribute to the degradation of bone. Although further studies needs to be conducted to ensure its long term efficacy and safety.

Major Theme: Impact of Physical Therapy Interventions on Senile Osteoporosis

The possible effects of physical therapy intervention on senile osteoporosis were covered in six of the twelve articles that remained. Since physical therapy's potential was discovered to be diverse, four main topics emerged, which are covered below.

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Theme 1: Effect of Multicomponent Exercise Programs on Bone Density

The exercises can have varied effects on the bone health. Thereby, a further sub-theme emerged whereby, the potential benefits with respect to the type of exercise were found.

Sub-theme 1: Effect of Resistance exercise on Balance Training

Stanghelle et al. (2020) conducted a 12-week intervention program on older women who have suffered from osteoporosis and vertebral fractures. Multicomponent exercise programs that combine resistance and balance training may have utility in delivering osteoporosis management to enhance bone health and reduce fall risk. Stanghelle et al. (2020) conducted a 12-week intervention program on older women who have suffered from osteoporosis and vertebral fractures. The program did have a moderate direct effect on BMD, although it had significant improvements in muscle strength, dynamic balance, and reduced fear of falling. Thus, it has the potential to address very important needs of those with osteoporosis who have an increased risk for fractures through falls.

Subtheme 2: Combined Strength and Aerobic Training

Dynamic combined training has proved to possess multiple additive benefits on functional strength and musculoskeletal health. Huang et al. (2021) demonstrated the critical point in the combination of both aerobic and strength training in the 12-week intervention program aimed at building muscle strength and rate of force development. It must be noted that it is necessary for the performance of tasks like standing and walking. In addition, significant findings regarding enhancements observed in RFD are underscored as crucial for the preservation of independence among aged people. Although promising the results were, still the study highlights more structured programs for elderly patients who are under supervision for safety and regular attendance.

Theme 2: Gait Improvement among Patients

Programs of functional training oriented towards balance and gait improvement appear to strengthen bone density while lowering fall risks. Puente-Gonzalez et al. (2021) have published a study on a 6-month multimodal exercise programme in the elderly patients with Alzheimer's disease. Subsequently, it found a significant gain in all the dimensions related to the stability of gait, balance, and strength of the lower limbs was reported with significantly low falls rates. If the program works for people with Alzheimer's, this type of functional training will improve their physical stability and reduce their risk potential in many elderly and more vulnerable populations. However, continued success would depend upon continued participation, or structured and accessible programs. Thus, it highlights a need for individualized training protocols to meet the needs of geriatric patients.

Theme 3: Mind-Body Interventions and Bone Health

The physical therapy interventions were very significant to the mind and body. Baduanjin Qigong was investigated by Yuen et al. (2021) to have effects on elderly stroke patients and showed great improvement in balance, leg strength, and general mobility. In general, Baduanjin Qigong was known to be an emerging form of exercise that is low-impact yet effective in preserving bone strength and joint steadiness in populations during their elderly year. This study has demonstrated that Qigong may provide a safe approach to muscle strengthening with an improvement in balance through reduced risks of falls, some serious concerns in the management of osteoporosis. Moreover, controlled weight-bearing movements with slow movements in Qigong indicate its application in cases of osteoporosis. Most importantly, slow, flowing movements and the postural transitions have been included in Qigong.

Subsequently, it demand stability and control that add to enhancing flexibility and strength of the joints without compromising joint integrity. This benefit is particularly valuable for patients with osteoporosis who may not tolerate high-impact or vigorous exercise programs. Moreover, Krumov et al. (2022) compared group-based rehabilitation with individual therapy post-total knee arthroplasty and found group

Journal of Ecohumanism
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settings give higher improvements in mobility and quality of life. This could be attributed to social interaction and support. The social aspect could become extremely useful for elderly osteoporosis patients who would be encouraged to participate regularly. Thus, it emphasize the physical and psychological benefits of mind-body interventions.

Theme 4: Guidelines for Therapy

Hartley et al. (2022) established guidelines recommending progressive resistance and weight-bearing exercises tailored to reduce bone mineral density (BMD) decline in the hip and lumbar spine in elderly osteoporosis patients. The guidlines consisted of an exercise physiologist and six physical therapists with clinical and methodological expertise. These recommendations align with findings from multicomponent exercise trials. These highlight the importance of customized, long-term exercise plans targeting skeletal regions most vulnerable to osteoporosis. These guidelines further highlight the potential of physical therapy in combination with nutrition and drugs to maintain a manageable life among older adults.

Major Theme: Potential Synergistic Benefits Of Multimodal Approaches In Managing Senile Osteoporosis

The remaining six studies discussed the potential synergistic benefits of multimodal approaches in managing senile osteoporosis. Based on the insights on the papers, three main themes were identified as discussed below.

Theme 1: Combination of Nutrition and Physical Exercise

Nutrition in maintaining bone health was found to be through managing bone density and bone turnover. Groenendijk et al. (2020) investigated a 24-week program that combined fortified milk supplements with exercise in older Chinese adults. Consequently, they found notable improvements in vitamin D and B12 levels. This study emphasizes how targeted nutrition, coupled with exercise, can help counteract bone density loss, which is essential in managing osteoporosis. The findings indicated reduced bone remodelling and potentially lower fracture risk due to increased bone stability. However, the study was focused on middle-aged Chinese individuals. This targeted sample might compromise the generalizability of the finding. However, similar findings have been found by Dedes et al. (2020) who compared three groups receiving calcium and vitamin D through diet, supplements, and pharmacological interventions, observing the greatest bone density improvement. Therefore, physical therapy and nutrition together may be a helpful approach to managing and preventing osteoporosis.

Theme 2: Combination of Nutrition and Physical Exercise

Dedes et al. (2020) also found that both drug and supplementations cases can prevent major osteoporosis cases. In addition, Outayanik et al. (2017) reported that 8 weeks of NME program improves physical fitness. The systematic physical exercises aside from increasing joint stability and muscle strength also protect the bones against falls and fractures, part of the osteoporosis management. The following were considered for inclusion: muscle strength, balance, and cardiorespiratory function. Thus, the results suggest the benefits of a multimodal intervention consisting in dietetic, pharmacological, and physical treatments in osteoporotic patients.

Theme 3: Challenges to Management

A unique theme emerging was the potential aspects of multimodal intervention programs. For instances, Zhang et al. (2020) reported that the community-based health programs for the elderly increased the adherence of patients with osteoporosis to their treatment in Shanghai. Similarly, Marshall et al. (2020), observed a correlation between poverty and increased susceptibility to osteoporosis, attributed to poor intake of calcium and vitamin D in the aged. This suggests that there is a need for targeted support in preparation of these multi-modal plans to prevent senile osteoporosis. Furthermore, it implies that there is a significant contribution of socioeconomic factors to the management of osteoporosis, majorly in access

Journal of Ecohumanism
2024
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to key nutrients. Therefore, the implementation of community health programs into a multi-modal strategy could present an effective sustainable approach toward bone health improvement. Subsequently, increasing the chances of fostering dietary and treatment compliance vital for the effective management of osteoporosis. This could work through local health centres helping to provide fairly necessary support and aftercare.

Discussions

This literature review presented an important fact that nutritional, pharmacological, and physical interventions synergistically delay senile osteoporosis. Nutritional intervention alone has been deemed crucial for bone metabolism but not decisive for BMD. In fact, the poor bioavailability of calcium and vitamin D in diets is a major drawback in plant-based diets that could compromise bone density. It was discovered that postmenopausal women, among old vegans, are prone to higher risks of a fracture associated with the scarcity of calcium and vitamin D (Webster et al., 2023). On the other hand, the Mediterranean diet was useful because of its anti-inflammatory and antioxidant benefits. Other studies disclosed that the adherence of the MD reduces the risk of osteoporosis up to 21% within the elderly population (Palomeras-Vilches et al., 2019). This is strongly attributed to high intakes of fruits, vegetables, and omega-3 fatty acids that support bone homeostasis. However, this is a regional diet and might not be followed among all populations at risk.

On the other hand, when combined with exercise, nutrients contribute more effectively to bone remodelling. For instance, the review identified weight-bearing exercises are particularly effective. This aligns with existing studies which found that resistance training can aid in increasing muscle mass and strength in older people (Borst, 2004). This increased muscular strength can aid in addressing the bone structure positively counteracting the degenerating effects of aging. Additionally, similar to Qigong, existing studies found Tai Chi equally useful ((Kurt et al., 2018; Song et al., 2010). These are capable of enhancing functional stability, and helping prevent falls which might exacerbate the rate of degeneration. However, adherence remains challenging, emphasizing the need for interventions (Kurt et al., 2018). Thus, there is a need for structured programs.

Furthermore, various useful pharmacological treatments were identified in the study. Studies have found that romosozumab is capable of preventing osteoporosis by targeting Wnt signalling (Iolascon et al., 2020). While the success of the integrative approach of exercise and pharmacology was identified in the current study, it supports the idea that mechanical strain from exercise enhances the anti-resorptive effects for a stronger stronger bone matrix. In the same way, the multimodal approach also tackles socioeconomic barriers for osteoporosis care. Community health efforts are able to improve treatment adherence and nutrient intake in the poor elderly population. The model, in that regard, recommends that incorporating community support into the multimodal management of osteoporosis can support the sustained adherence especially in the under-resourced settings. Standardized protocols for multimodal osteoporosis interventions become important while addressing the issue of patient variability and accessibility. These protocols should include tailored approaches that combine pharmacological, nutritional, and physical therapy elements while taking into consideration accessibility for diverse groups of socioeconomic status.

Conclusion

A multimodal approach that integrates nutritional, pharmacological, and physical therapy interventions presents a promising strategy for delaying the progression of senile osteoporosis. Pharmacological treatments like bisphosphonates and newer agents such as romosozumab are vital for those with severe bone density loss, although challenges in adherence and safety considerations call for personalized regimens. On the other hand, nutritional interventions supply essential support for bone health, with diets rich in calcium, vitamin D, and anti-inflammatory compounds showing specific benefits. However, nutrition alone may not significantly improve bone mineral density, highlighting the importance of combining it with other therapies. Physical therapy, especially resistance and weight-bearing exercises, enhances these efforts by increasing bone strength, muscle function, and stability, thus reducing the risks

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2024
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of fractures and falls. Thus, these interventions together can address the complex, multifactorial nature of osteoporosis, not only by strengthening bone structure but also by enhancing functional capacity and reducing injury risks.

However, this systematic review has several limitations. First, reliance on existing studies may have introduced publication bias, as studies with positive outcomes are more commonly published than those with neutral or negative results. Additionally, variations in methodologies, sample sizes, and geographic diversity complicate direct comparisons and limit the generalizability of findings. However, the finding has various practical implications. Such as this review supports the adoption of a multimodal approach to osteoporosis management, integrating nutritional, pharmacological, and physical therapies. Additionally, establishing guidelines to promote adherence to both dietary and medication plans could enhance treatment effectiveness. Future research may follow long-term randomized controlled trials to assess the lasting effects of combined nutritional, pharmacological, and physical interventions on osteoporosis management. Additionally, investigating the cost-effectiveness and accessibility of multimodal interventions, particularly in low-resource settings could be instrumental.

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2024
Volume: 3, No: 8, pp. 11012 – 11038
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
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2024
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https://ecohumanism.co.uk/joe/ecohumanism
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Appendix

Literature Table

Author and Year	Aim	Sample	Study Method	Findings	Implications
Thorpe et al. (2021)	To understand the relationship between hip fracture risk and dietary habits, specifically focussing on whether vitamin D and calcium supplements affect fracture risk in vegans.	34,542 non-Hispanic white peri- and postmenopausal women and men 45 year	Cohort Study	Higher hip fracture risk was found among female vegans compared to nonvegetarians (NVEGs), but supplementation with calcium and vitamin D eliminated this risk. No association was found between diet and hip fracture risk in men.	Combined supplementation of calcium and vitamin D is essential to reduce hip fracture risk.
Benetou et al. (2018)	This study explored an existing association between adherence to the Mediterranean diet with the incidence of hip fractures in old adults	The total sample size included 140,775 adults with 24,599 men and 116,176 women aged 60 years and above from the five cohorts of Europe and USA followed up for	Cohort study	A two-point increase in the score was associated with a substantial 4% decrease in the incidence of hip fractures (pooled adjusted HR 0.96; 95% CI 0.92-0.99, pheterogeneity = 0.446). In categorical analyses, the risk	Among older adults cohorts from USA and Europe increased adherence to the Mediterranean diet could result in lower incidence of hip fractures.

Journal of Ecohumanism
2024
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https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5708

		1,896,219 person-years having experienced 5454 hip fractures.		of hip fractures was lower for men and women who adhered to the score moderately (HR 0.93; 95% CI 0.87-0.99) and highly (HR 0.94; 95% CI 0.87-1.01) than for those who did not.	
Papageorgiou et al. (2020)	To Establish the Association of Dietary Acid Load with Bone Health in Aging: Changes over Time in Density, Microstructure, and Bone Strength	853 healthy 65 year old menopause women and men; with 708 followed over 6.1 years	Cohort Study	A greater intake of a diet with higher DAL (Acid-D) resulted in lesser age-related bone loss in older women when compared with those on an alkaline or neutral diet. No association was found between DAL and the incidence of fracture risks.	Higher protein and phosphorus intakes in Acid-D diets might have beneficial effects on bones. The evidence does not support the original premise that acid-producing diets impair bone health in well-nourished older adults for DAL.
Fung et al. (2019)	To assess whether alcohol consumption, and consumption of certain beverages, is associated with risk of hip fracture among older adults.	Biennial questionnaires between 1980 and 2014 in 75,180 postmenopausal women from the Nurses' Health Study, and between 1986 and 2014 in 38,398 men aged ≥50 y from the Health Professionals Follow-Up Study.	Cohort Study	Moderate alcohol consumption-or more specifically, among women, red wine-was associated with a lower risk of hip fracture. For hip fracture, higher alcohol consumption increased the risk. Red wine had the strongest protective association among women, and no beverage effect was found for men.	Moderate light levels of alcohol intake especially in terms of red wine may be indicative of benefits towards bone health in aging adults. The study results indicated new avenues towards further work on possible action of compounds in red wine on bone health.
Itkonen et al. (2020)	To determine the effect of	145 healthy adults	Randomized Clinical Trial	This diet rich in plant-based	Adequate intake of

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	partial substitution of animal proteins with plant-based proteins on bone turnover and mineral metabolism in healthy adults.	107→women 29→men		proteins had higher markers of bone turnover and may pose risks to the skeleton; the diet was lower in both calcium and vitamin D and may facilitate rapid bone turnover.	calcium and vitamin D is important regarding shifting towards plant-based diets because it prevents possible negative effects on bone health. Additional research is also required to assess the long-term effects.
Guo et al. (2023)	It aimed to study Duck egg white peptides (DPs), which may act against osteoporosis through osteogenesis pathways.	MC3T3-E1 preosteoblast cells and ovariectomized (OVX) rat model.	In vitro and In vivo anaysis	DPs, activated through the Wnt/β-catenin signaling pathway, enhanced osteogenesis, expressions of osteogenic markers (Runx2 and OPG), bone microstructure, calcium influx, and bone turnover in the OVX rats.	DPs therefore present great promise as a natural therapeutic against the prevention of osteoporosis. This may enhance high-value utilization of salted duck egg by-products in the treatment of osteoporosis.
Shahnazari et al. (2019)	To compare vitamin D levels among osteopenic, osteoporotic, and healthy people and to study its effect on BMD.	400 patients from Kowsar	Clinical trial with serum vitamin D testing and DEXA	Association of lower vitamin D levels with osteoporosis. A significant increase in the BMD after 8-week supplementation of vitamin D in deficient subjects	Maintenance of a regular level of vitamin D supplementation improves bone density and prevents the risk of osteoporosis, mainly in the elderly and in women.
Ballesteros et al. (2019)	To evaluate the association between adherence to a Mediterranean diet and falls risk in older adults.	2071 adults Spanish 60 years age for 3.5 years	Cohort Study measured by the MEDAS score, and self-reported incidence	Higher adherence to the Mediterranean diet- mainly high vegetable intake was related to lower falls risk.	There is a cumulative or synergistic benefit of the Mediterranean diet on muscle and bone health that could reduce the fall

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	Prospective cohort study				risk in older adults. This study should be extended to measurement of healthcare needs and injuries resulting from falls.
Allam et al. (2023)	This study aims to examine the protective effects of probiotic Lactobacillus acidophilus on osteoporosis in aging rats and explores the involvement of the NLRP3 inflammasome pathway.	32 adult albino rats	Experimental Study	Probiotic treatment reduced oxidative stress significantly, lowered serum calcium, increased bone formation markers, decreased bone resorption markers, lowered NLRP3 inflammasome activation, and increased bone density and architecture in osteoporotic rats.	Probiotic Lactobacillus acidophilus has the ability to prevent osteoporosis as a protective treatment with anti-inflammatory activities on the NLRP3 pathway, providing an inexpensive yet safe therapeutic method for preventing osteoporosis.
Benetou et al. (2018)	This study evaluated the association between adherence to the Mediterranean diet and incidence of hip fracture among older adults.	140,775 adult Age >60	Cohort Study	Each of the points above corresponds to an increment in the score of Mediterranean diet that had a corresponding correlation in reduction of the risk for hip fracture by 4%. Higher levels of MD adherence were associated with a reduced risk for hip fracture. The association was significantly more pronounced among women.	Being on the Mediterranean diet may reduce the risk of hip fractures, an additional benefit now obtained besides preventing chronic diseases and healthy aging.

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Wu et al. (2020)	To investigate the anti-inflammatory activities of geraniol through its impact on PI3K/Akt/NF-ϰB and MAPK signaling pathways in OA.	DMM mice model of OA, destabilization of the medial meniscus, and IL-1β-induced chondrocytes	Experimental Study	Geraniol suppressed inflammatory markers such as COX-2, iNOS, TNF-α, and IL-6 and reduced the MMP-9 and ADAMTS-5 matrix degradation enzymes with preservation of collagen and aggrecan content. It also suppressed activation of the PI3K/Akt/NF-ϰB and MAPK pathways in OA.	Geraniol is a potentially safe agent for OA interference that has targeted the interference with both inflammatory and pathways for cartilage degradation at an equal level with some alternatives.
Ishikawa et al. (2024)	To evaluate the impact of 3-month treatment with romosozumab on biomechanical parameters in elderly patients undergoing spinal instrumentation surgery for osteoporosis.	81 osteoporosis patients Age→ 60-90	Open-labelled prospective study	Romosozumab strongly increased vertebral and pedicle vBMD and biomechanical parameters (compression strength, screw pullout strength, cage subsidence strength), suggesting fewer postoperative complications than eldecalcitol.	In spinal instrumentation surgery for osteoporosis, perioperative treatment could play a positive role in conditions like this by reducing complications and promptly supporting bone health with romosozumab.
Narayanasamy et al. (2022)	To explore the acceptability and participation of older people in oral and intravenous bisphosphonates for the treatment of osteoporosis.	78 patients	Semi-structured interview	Intravenous bisphosphonates were more popular for lower burden, perceived greater effectiveness, and less complexity; oral bisphosphonates were limited by problems with adherence.	Consider making the intravenous option a first-line treatment for osteoporosis to increase adherence, particularly in patients who have problems adhering to oral regimens.
Kathagen et al. (2023)	To assess the secondary	43310 patients	Retrospective Analysis	Anti-osteoporotic	Intensive and continuous

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	fractures and surgical complications postoperatively after surgical fixation of fractures of the proximal humerus in the elderly who have been on anti-osteoporosis therapy.			therapy significantly reduced the incidence of secondary fractures, and further reduced the occurrence of surgical complications, with greater benefit to male patients.	early anti-osteoporotic therapy can prevent fractures and surgical complications, especially among males.
Cubria et al., (2020)	To characterize the musculoskeletal phenotype of the G608G progeria mouse model and determine the effects of treatment.	Lonafarnib, pravastatin, and zoledronic acid-treated G608G progeria mouse model	Experimental Study	Combined pravastatin and zoledronic acid significantly improved bone structure, density, and rigidity; cartilage degradation remained evident, though partially improved in combined treatment groups. lonafarnib alone had little impact on musculoskeletal parameters.	Combination therapy may offer advantages to skeletal integrity in HGPS, and further multi-drug approaches will be warranted.
Wu et al. (2023)	To understand the Protective effects of eugenol on chondrocytes and cartilage in osteoarthritis	OA mouse	Experimental Study	Eugenol inhibited apoptosis and degradation of chondrocytes and cartilage through the suppression of the JAK3/STAT4 pathway and prevented OA-related changes in the subchondral bone and cartilage.	Eugenol has been found as a novel therapeutic candidate for OA due to its efficacy in the regulatory pathways of inflammation and more studies are required for clinical application.
Lee et al. (2021)	To evaluate the anti-	Animal model	Experimental Study	Ginkgolide B increased the	Ginkgolide B is probably likely

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	osteoporotic efficacy of ginkgolide B on oxidative stress-induced bone homeostasis in osteoporosis.			values of bone density, attenuated oxidative stress, and normalised the OPG to RANKL ratio, which was all favourable for osteogenesis while inhibiting osteoclastogenes is in osteoporotic mice.	going to be a novel drug monotherapy for osteoporosis since it reduces oxidative stress and balances bone homeostasis which will support the clinical application.
Mugnier et al. (2018)	To assess the effectiveness of anti-osteoporotic therapy in reducing the risk of refracture in patients aged 75+ years in an FLS program.	204 patients Age→ 75 years	Observational study for 31 months	The anti-osteoporotic therapy reduced the incidence of refracture by 70% at 30 months. The difference in early fractures between treated and untreated groups was not found.	Regular usage of anti-osteoporotic therapy in elderly persons could reduce the long-term risk of refracture. FLS programs in elderly patients might improve the outcome of secondary prevention.
Nakano et al. (2021)	To investigate the efficacy of zinc pharmacotherapy in enhancing BMD in elderly osteoporotic patients with zinc deficiency.	122 elderly Japanese patients	Prospective Study	Zinc therapy substantially enhanced BMD at the lumbar spine, total hip, and femoral neck. Markers of bone formation increased, particularly among females.	Zinc therapy could be another form of intervention to enhance BMD and prevent fractures among older patients suffering from osteoporosis-related to the deficiency of zinc.
Puente-González et al. (2021)	To evaluate the results of a 6-month MPEP on the effects of Alzheimer's patients on bone mineral density, risk of falls, balance, and gait.	72 Alzheimer's patients	Experimental Study (Clinical trial)	Improvement in gait and balance in the intervention group. Reduced cases of falls. Bone health was maintained, which implies a slowing down of bone loss and	Multimodal exercise programs will thus be helpful to the patients with Alzheimer's in terms of their physical functioning and on reducing

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				deterioration. Control Group showed a highly significant declining trend in bone health.	falls. Interventions could also slow down the rate at which bone loss was progressing. Long-term studies are suggested for further follow-up.
Krumov et al. (2022)	To compare the effectiveness of group-based physical therapy compared with individual physical therapy to improve activity level and health-related quality of life in elderly adults after total knee arthroplasty	130 patients	Observational Study	Activity levels 6MWT distance and HRQoL scores were significantly more improved in the GBPT group compared with the IPT group in most of the domains of the SF-36v2.	This may provide better advantages of GBPT over IPT in post-TKA rehabilitation, implying that group-based approaches may improve outcomes of recovery in physical function and HRQoL in elderly populations.
Hartley et al. (2022)	To create a clinical practice guideline for the physical therapist to care for patients with osteoporosis.	-	-	Recommendations Progessive resistance strength training and weight-bearing exercises in postmenopausal women preserve BMD at the femoral neck, lumbar spine, and hip. In men, there is a lack of evidence; lifelong physical activity is suggested.	Long-duration and high-intensity exercise, modified for the risk factors of osteoporosis, should be included in the activities of physical therapists. The guidelines favour the prevention of falls and decline in fracture risk in clinical practice.
Stanghelle et al. (2020)	To study the effects of a multicomponent resistance and balance exercise	149 women	RCT	Improvement was dynamic but not static for the intervention group about	Multicomponent resistance and balance training can indeed enhance

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	program on older women with osteoporosis and vertebral fracture: physical fitness, health-related quality of life (HRQoL), and fear of falling.			balance and strength measures (arm strength, leg strength) as well as reduced fear of falling when compared with controls; however, no difference was reported in terms of HRQoL or walking speed.	strength and balance among elderly women afflicted with osteoporosis and vertebral fractures while reducing the fear of falling through exercise as appropriate non-pharmacological interventions.
Huang et al. (2021)	To evaluate the effects of dynamic combined training on muscle strength and RFD in middle-aged and elderly OP patients with knee OA.	58 patients	RCT	Significant improvements were noted for MVC and RFD within the OP group with significant increases in sizeable muscle strength; and in KOA, with no significant effect.	Dynamic combined training may have a positive influence on improving the strength of muscles and impulse response of patients with OP and KOA. In this regard, the training may thereby enhance the support of daily activities while reducing the risk of falls.
Yuen et al. (2021)	To determine if Baduanjin Qigong is effective in enhancing patients' balance and leg strength, as well as their mobility, who have experienced a stroke for years.	58 stroke patients	RCT 16 week	There was significant superiority of the Baduanjin group with significant improvements in balance, leg strength, and mobility when compared to controls. The results were maintained over time through home-based practice.	Baduanjin Qigong may serve as a safe, accessible, and sustainable exercise in the rehabilitation of stroke patients in enhancing their balance and mobility.
Groenendijk et al. (2020)	To investigate the effects of a nutrition and	180 Chinese patients	RCT 24 weeks	The intervention group displayed increases in	Supplementing with fortified nutrition

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	exercise intervention on middle-aged to older Chinese adults vitamin B-12 and 25-hydroxyvitamin D levels and bone turnover markers.			vitamin B-12 and 25(OH)D levels with a positive shift in bone turnover markers showing reduced bone remodelling as compared with controls.	combined with exercise appears to have the potential to improve vitamin and bone health in older adults, and, consequently, can likely be beneficial in the prevention of osteoporosis.
Dedes et al., (2020)	Comparison of effects of nutrition, supplements, and drug interventions on bone density in osteopenic patients over one year.	100 women	Experimental Study	Both T and Z scores of all treatment groups increased; the greatest change was, however, found in the treatment group that received drugs + supplements. There was no significant difference among those treated with nutrition and supplementation.	Therefore, drug intervention with supplements may be more appropriate for patients who have low T scores. Nutrition alone or with supplements is beneficial but less potent.
Outayanik et al. (2017)	This study aimed to determine the effects of an 8-week program of physical activity, specifically Nine Matrices Exercise, on the nutritional status and health-related physical fitness of older adults in Bangkok.	35 older adults Age → 65-75 years	8-week intervention with NME,	Mean weight, BMI, cardiorespiratory fitness, muscular strength, flexibility and agility/balance changes showed significant improvements, while mean blood pressure did not present a change.	The NME program can be an effective strategy to enhance physical fitness and nutritional health for the older population. Furthermore, NME can be adapted as a cost-effective alternative for elder care.
Zhang et al., (2020)	The aim is to measure the prevalence and risk factors of osteoporosis among the	565 individuals Age→ >70	Cross-sectional study	The prevalence of osteoporosis was 39.5%. The risk factors are as follows: gender, female; ageing;	The monitoring of early BMD and BTMs can be helpful in the early diagnosis and

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	elderly population aged above 70 years in Shanghai.			poor self-care ability; and malnutrition. Positive correlations exist between BMD and BTMs like P1NP, N-MID, and 25OHD; β-CTX has a negative correlation with BMD.	management of OP, particularly in communities. Nutritional support and enhanced self-care activities should be encouraged among the elderly.
Marshall et al. (2020)	To study the relationship between indicators of poverty, calcium/vitamin D intake, and risk of osteoporosis among older Americans.	3,901 adults Age→>50	Cross-sectional analysis of NHANES data	Among women aged 50 and over, at all poverty levels, more than 90% of the nutritional intakes of both nutrients were below the NHANES III/USDHHS recommended adequacy levels. Poverty had a positive relationship with higher risk for both inadequate calcium intake and osteoporosis among men, particularly Non-Hispanic Blacks.	Reduction in risk of osteoporosis could be achieved through calcium/vitamin D supplementation, especially among low-income and food-insecure populations, with therefore being the focus of targeted interventions.