

# Osteoporosis – risk factors, pharmaceutical and non-pharmaceutical treatment

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**Abstract.** – Osteoporosis is a metabolic disease of the skeletal system which currently affects over 200 million patients worldwide. The WHO criteria define osteoporosis as low bone mineral density, with a T-score  $\leq -2.5$  found in the spine, the neck of the femur, or during a full hip examination. Osteoporosis considerably reduces a patient's quality of life. QoL should be carefully evaluated before fractures occur to enable the development of an appropriate treatment plan. The progression of osteoporosis may be significantly inhibited by following a proper diet, leading a healthy lifestyle, taking dietary supplements, and receiving appropriate treatment. Education and the prevention of the disease play a major role. Potentially modifiable risk factors for osteoporosis are vitamin D deficiency, smoking, alcohol consumption, low calcium intake, low or excessive phosphorus intake, protein deficiency or a high-protein diet, excessive consumption of coffee, a sedentary lifestyle or lack of mobility, and insufficient exposure to the sun. Pharmaceutical treatment for osteoporosis involves bisphosphonates, calcium and vitamin D3, denosumab, teriparatide, raloxifene, and strontium ranelate. Data indicates that 30%-50% of patients do not take their medication correctly. Other methods of treatment include exercise, kinesitherapy, treatment at a health resort, physical therapy, and diet.

*Key Words:*

Osteoporosis, Risk factors, Treatment, Physiotherapy, Diet.

## Introduction

Osteoporosis is a metabolic disease of the skeletal system. It is a widespread public health issue that may lead to disability, especially among the elderly. Due to its insidious, asymptomatic course, it is often first diagnosed when a fracture occurs. The most common fractures are verte-

bral, followed by hip fractures and distal forearm fractures. Osteoporosis typically has a silent, insidious course<sup>1</sup>.

According to data from the International Osteoporosis Foundation, the disease currently affects over 200 million women. It mostly affects women above 60 (60%) and men above 70 years of age (20%). Approx. 30% of women and 20% of men aged 50 and above experience osteoporosis-related fractures. In 2010, 21 million men and 137 million women were at risk of osteoporotic fractures. The number of patients at high risk of osteoporosis fractures is expected to rise from 158 million in 2010 to 319 million in 2040. According to a 2010 report, 22 million women and 5 million men had been diagnosed with osteoporosis in EU member states, and the number of fractures stood at 3.5 million. In Poland, there are approx. 2 million patients aged 50 and above with osteoporosis. When it comes to osteoporotic fractures, they occur in 30% of women and 8% of men in the same age group. According to estimates, overall one in three women and one in five men over 50 will experience an osteoporotic fracture. Fracture risk increases with age and is much higher in women<sup>2,3</sup>.

The World Health Organization (WHO) criteria define osteoporosis as low bone mineral density, with a T-score  $\leq -2.5$ , found in the spine, the neck of the femur, or during a full hip examination. However, the definition does not include cases of patients with normal bone mineral density who have experienced an osteoporotic fracture, among others. This is extremely important, as 75% of these fractures occur in patients with signs of osteopenia. Bone strength depends both on bone mineral density and on bone tissue quality. Therefore, in 2001, the National Institute of Health (NIH) developed a definition of osteoporosis as a generalized skeletal system disease

associated with decreased bone strength and an increased risk of fractures<sup>3-5</sup>.

Osteoporosis considerably reduces the patient's quality of life (QoL) and is associated with high rates of morbidity and mortality from comorbidities. It may result in greatly reduced physical performance and permanent disability. The progression of osteoporosis, especially in its initial stages, may be significantly limited by following a proper diet, leading a healthy lifestyle, taking dietary supplements, and receiving appropriate treatment. Education on the disease and its prevention plays a major role<sup>6-9</sup>. Table I provides the clinical classification of osteoporosis.

**Risk Factors**

Bone tissue loss, occurring progressively with age, is a natural process associated with slowing metabolic processes in the body. The process may be accelerated by certain adverse factors, both

modifiable and non-modifiable.

Non-modifiable factors account for most of the risk of osteoporosis and include:

- Advanced age
- Female sex
- Familial predisposition
- Caucasian race
- History of fractures in adulthood
- Dementia
- Poor health
- Delicate constitution

Potentially modifiable risk factors for osteoporosis include:

- Vitamin D deficiency
- Smoking
- Alcohol consumption
- Low calcium intake
- Low or excessive phosphorus intake
- Protein deficiency or high-protein diet

**Table I.** Osteoporosis classification – by stage of disease progression.

Stage	Symptoms	Clinical features	Radiographic features
Early	<ul style="list-style-type: none"> <li>• Pain in the spine and upper extremities</li> <li>• Feeling down, sometimes depression</li> <li>• Possible intercostal pain at maximum inspiration</li> </ul>	<ul style="list-style-type: none"> <li>• Postural defects that may be actively corrected by the patient</li> <li>• Increased paraspinal muscle tension</li> <li>• Abdominal and gluteal muscle weakness</li> <li>• Paraspinal muscle tenderness</li> <li>• Painful but unrestricted active spine movement</li> </ul>	<ul style="list-style-type: none"> <li>• No lesions typical for osteoporosis</li> <li>• Osteopenia in densitometric examination</li> </ul>
Advanced	<ul style="list-style-type: none"> <li>• Pain in the spine typically increasing during movement</li> <li>• Feeling down, often depression</li> </ul>	<ul style="list-style-type: none"> <li>• Postural abnormalities, increased cervical and lumbar lordosis and thoracic kyphosis</li> <li>• Active posture correction is not fully possible</li> <li>• Abdominal wall laxity and depression of the ribs</li> <li>• Skin folds on the back arranged in a herringbone pattern</li> <li>• Less pronounced waist indentation</li> </ul>	<ul style="list-style-type: none"> <li>• Decreased vertebral body saturation</li> <li>• Loss of horizontal trabecular pattern</li> <li>• Thinning of the cortical layer</li> <li>• Sometimes — reduced vertebral body height</li> <li>• Osteoporosis in densitometric examination</li> </ul>
Late	<ul style="list-style-type: none"> <li>• Constant spinal pain increasing with movement</li> <li>• Abnormal posture</li> <li>• Loss of height</li> <li>• Avoidance of social contacts and physical effort</li> <li>• History of lower and/or upper extremity fractures</li> <li>• Hips and knees bent when standing</li> </ul>	<ul style="list-style-type: none"> <li>• Fixed thoracic kyphosis</li> <li>• Pain while trying to correct the kyphosis</li> <li>• Increased cervical lordosis and forward head tilt</li> <li>• Abdominal wall laxity</li> <li>• Depression of the rib cage, at times with ribs in contact with the ala</li> <li>• Weakened abdominal, gluteal, leg, and arm muscles</li> <li>• Tenderness of paraspinal muscles and spinous processes of vertebrae</li> </ul>	<ul style="list-style-type: none"> <li>• Lesions typical for osteoporosis</li> <li>• Healed fracture sites</li> <li>• Osteoporosis in densitometric examination</li> </ul>

- Excessive consumption of coffee
- Sedentary lifestyle or lack of mobility
- Insufficient sun exposure<sup>10-13</sup>.

In Table II the consequences of osteoporosis are presented.

### Treatment of Osteoporosis

Physical, emotional, and psychological disability, combined with the pain experienced after a hip, spine, or wrist fracture, considerably affect the patient's QoL. QoL in men and women with osteoporosis should be carefully evaluated before fractures occur, so as to enable the development of an appropriate treatment plan with a view to alleviating patients' symptoms at all stages of the disease. Specialists treating osteoporosis within a comprehensive treatment plan have identified two stages of intervention:

**Stage I – primary care including:** (1) screening: taking the patient's history and carrying out a physical examination, an assessment of muscle strength, assessing clinical risk factors for fractures (FRAX) and risk factors for falls; (2) early prevention; (3) further diagnostics for osteoporosis.

**Stage II – specialist care:** (1) differential diagnosis; (2) detailed evaluation of all fracture risk factors, including sarcopenia and frailty syndrome; (3) education; (4) effective pharmaceutical and non-pharmaceutical treatment (physical therapy, fall prevention, vitamin D supplementation, diet modification, monitoring of treatment).

Osteoporosis prevention includes:

- Optimizing peak bone mass in young adults.
- Implementing a four-stage diagnostics plan for patients with clinical risk factors for osteoporotic fractures.
- Accurately measuring bone strength.

- Minimizing gaps in treatment.
- Using new, safer and more effective medications.
- Providing optimal pharmaceutical and non-pharmaceutical treatment (interventions including specific exercises to improve muscle strength and balance, reduce pain, and improve subjective QoL).
- Using new treatment strategies: defining and targeting high-risk patients<sup>5</sup>.

### Pharmaceutical Treatment

Pharmaceutical treatment for osteoporosis most commonly involves the use of bisphosphonates, which must be accompanied by calcium and vitamin D3 supplements and regular blood tests. Another drug used in the treatment of osteoporosis, both in first-line therapy and at subsequent stages, is denosumab. It inhibits osteoclast activity, producing a rapid but reversible antiresorptive effect. In severe osteoporosis with fractures, once other drugs have proven ineffective, teriparatide may be used. It is a parathyroid hormone derivative and a strong promoter of bone formation. However, due to its high price and the fact that it is non-refundable through the National Health system, the drug is virtually unavailable in Poland. The situation is similar with raloxifene, which may additionally cause complications such as thrombosis and hot flushes. The risk of fracture may be effectively reduced by strontium ranelate, which inhibits bone resorption and promotes bone formation. However, the drug has adverse cardiovascular effects and is not available in Poland<sup>5,14</sup>. The medications applied in osteoporosis have been summarized in Table III.

Despite the high risk of death, with the mortality rate within one year of the femoral fracture reaching 15-40%, poor patient compliance is common. Epidemiological data indicates that approximately 30-50% of patients do not take

**Table II.** Consequences of osteoporosis.

Consequences of osteoporosis	
<p><b>Physical</b> Fractures Reduced physical performance Difficulty performing daily activities Chronic pain Upper back kyphosis – “dowager’s hump” Gastrointestinal disorders: bloating, pain, difficulty in passing stools, sense of fullness Loss of height</p>	<p><b>Social and psychological</b> Sleep disorders Quality of life deterioration Depression Social isolation Deterioration of economic and financial standing Disability</p>

**Table III.** Medications in osteoporosis treatment.

Drug	Dosage form	Additional information
Alendronate	Tablets	–
Ibandronate	Tablets/prefilled syringe	Only used in postmenopausal osteoporosis, to reduce the risk of spinal fracture. Not recommended for men
Risedronate	Tablets	–
Zoledronate	Solution for infusion	–
Denosumab	Prefilled syringe	Not effective in glucocorticoid-induced osteoporosis
Raloxifene	Tablets	Only used in postmenopausal osteoporosis to reduce the risk of spinal fracture. Not recommended for men. Rarely used due to the possible adverse effects
Teriparatide	Solution for injection	Does not improve the risk of femoral neck fracture.
Strontium ranelate	Granules for oral solution	Not effective in glucocorticoid-induced osteoporosis. Use restricted due to possible thromboembolic complications.

their medication correctly. Most patients discontinue treatment within the first three months, but some do not even start the prescribed treatment at all or stop it soon after starting. Only one in two patients still continue treatment after a year, and one in three – after two years. As shown by published analyses, only one in four patients comply with the treatment recommendations they receive. The main reasons for non-compliance include: lack of motivation to continue treatment, lack of symptoms at the initial stage after diagnosis, progression of the disease while on medication, adverse effects of treatment or fear of adverse effects, lack of knowledge regarding the consequences of non-compliance, and lack of belief that the medication is helping. Problems with communication between the physician and the patient are reported as another reason for inadequate compliance with treatment in this patient group. According to physicians, lack of understanding on the part of the patient is the main cause for the discontinuation of treatment in 12% of cases. However, among the 85% of physicians who reported having patients who had discontinued their osteoporosis treatment, as many as 71% did not know the reason for this. The vast majority of physicians do not know how to effectively motivate their patients. They mostly discuss the consequences of non-compliance but are unable to improve patients' motivation. According to patients, the best motivator is the possibility of keeping one's independence and autonomy if they regularly take their medication.

One factor that often adversely affects adherence is difficulty with medication protocol and the frequency of dosage. Research demonstrates that a switch from daily to weekly doses significantly improves treatment outcomes. Patients who can take their medication less

often are shown to be clearly more persistent. Patients are also more likely to take medications that cause fewer restrictions in their daily activities. Bisphosphonates must be taken on an empty stomach and require the patient to remain upright for at least 30 minutes, which makes weekly administration far preferable to daily administration.

#### **Other Treatment Methods**

Other treatment methods for osteoporosis, used in conjunction with pharmaceutical treatment:

**Exercise with osteoporosis:** As the percentage of elderly individuals in society continues to increase, more physicians are becoming interested in osteoporosis. Recent research has confirmed the significant role of physical activity in the rehabilitation of patients with osteoporosis. Expected benefits of regular exercise include:

- Reduction of pain,
- Prevention of falls and fractures,
- Activation of the sensorimotor system,
- Improved mobility,
- Improved subjective QoL<sup>15</sup>.

#### **Kinesitherapy in the early stages of osteoporosis:**

These interventions include education on maintaining proper posture and doing anti-kyphosis exercises, including individual and group exercises for spinal unloading, complemented with resistance exercises. The load on bone structures associated with an upright position is considered to improve mineralization. There is no unanimity on the effectiveness of kinesitherapy with bodyweight unloading (in a pool). Water at 25-30°C enables free movement and perfectly complements the therapy. At lower temperatures, muscles may become

cold and stiff, while higher temperatures may accelerate the onset of fatigue, especially in the elderly. Important aspects at this stage also include coordination and balance training, as well as gait improvement. These interventions' main objectives include increasing patients' independence, delaying aging, and promoting the principles of ergonomics, including the correct ways to sit down, stand up, lie down, and lift and carry objects.

**Kinesitherapy in advanced osteoporosis:** At this stage, the bone structure becomes altered. Exercises should focus on promoting bone tissue regeneration, delaying demineralization, and improving muscle strength and physical function. Orthopedic appliances are used at this stage, and patients are taught to stand back up after a fall. Besides crutches, walking sticks, and walking frames, neck braces may be used to reduce cervical spine overload due to spinal muscle strain.

**Kinesitherapy in late osteoporosis:** Fractures and changes in body shape make it impossible to restore correct posture, but continued corrective exercises suited to each patient's condition can still be helpful. These exercises focus on reducing pain by regulating muscle tension and unloading bone structures. Kinesitherapy involves exercises to improve lung ventilation, and isometric exercises to relax muscles in the limbs and torso. In patients with fractures, it is crucial to accelerate healing and enable safe, independent walking using supports such as walking frames and orthotics. These supports are used for a period of time, depending on the severity of pain and how fracture healing progresses. They must be combined with exercises to maintain bone density. In many cases, the only appropriate solution involves the constant use of neck and back braces, protecting the patient from subsequent trauma.

The effectiveness of physical exercises in terms of maintaining appropriate bone mineral density and preventing fractures has been demonstrated in research.

#### ***Most Commonly Used Exercises***

1. Breathing exercises – these are particularly important in the elderly population, as they reduce the extent of involuntal changes that have already occurred in the respiratory system, causing restrictions in activity. Exercises

must be performed correctly so as to improve oxygen uptake and distribution to tissues. Pain can interfere with breathing and movement. Inhalations and exhalations are shallow, with minimal engagement of the respiratory muscles and only slight chest movements. Accumulation of mucus and problems with evacuating it is also a problem. Breathing exercises must increase the patients' respiratory performance and vital lung capacity and teach them to expectorate and cough without exacerbating pain. During these exercises, care must be taken to ensure patient safety and protect the weakened bone structures.

2. Exercises to improve posture and joint mobility – the weakening of bone structures associated with osteoporosis leads to the alteration of the normal curvature of the spine, and the resulting pain restricts the patient's movement, interfering with physical activity and perpetuating the abnormalities. Movement is also hindered by contractures in the limbs and joints. Initially, passive and semi-passive exercises are advised as they can improve joint mobility. They should be followed by a gradual recovery of proper posture and the elimination of bad postural habits.
3. Resistance exercises for all muscle groups. Proper posture during exercise is of the utmost importance, as it ensures that bone structures are not overstressed. All exercises are performed slowly, with a gradual increase in both load and range.
4. Balance exercises – disorders connected with balance can be caused by: impaired functioning of the vestibular system, neuromuscular conduction and vision, vertigo, and muscle. These disorders may prevent the patient from reacting correctly to balance disturbances, leading to particularly dramatic falls in elderly people. Therefore, these exercises aim to improve the patient's ability to verify the sensory information coming from their environment, promoting neural flexibility and strengthening the coordination between proprioception, vision and the vestibular sense.
5. Training for everyday activities – exercises to improve joint mobility, muscle strength and coordination, so as to ensure physical fitness sufficient for independent functioning in life and to improve QoL.
6. Water exercises – the recommended water temperature of 25-33°C allows for a greater range of motion, and buoyancy in water reduc-

es pain, enabling the patient to overcome any psychological barriers more easily.

In a study by Angin et al<sup>4</sup>, there was a significant increase in bone mineral density in patients who participated in Pilates-based exercises for 6 months. Moreover, exercise has been shown to be as effective as a pharmaceutical treatment in reducing the risk of osteoporosis in postmenopausal women. Additionally, Pilates exercises prevent musculoskeletal injury by strengthening pelvic and upper body muscles. Active participants also had significantly greater muscle strength, flexibility and endurance, compared to controls.

Another study on postmenopausal women with osteopenia evaluated the impact of 24 weeks of aerobic dance exercises on bone mineral density, physical fitness, and QoL. Findings indicated that participation in aerobic dance exercises could result in fewer fractures due to higher bone mineral density and a reduced risk of falling. There were statistically significant differences between active participants and controls in terms of pain, levels of physical activity, social life, and perceived health. All of the patients regularly took bisphosphonates, calcium, and vitamin D. Those who engaged in osteoporosis-focused exercises had a significantly better QoL than those who did not<sup>16</sup>.

There are various exercise programmes dedicated to osteoporosis patients, which are designed to help improve bone mineral density and prevent falls and fractures. Their effectiveness in this regard has been demonstrated through research. Positive outcomes were observed after aerobic exercises, weight training, and resistance band training. Research has shown that patients with osteoporosis who performed exercises using TRX exercise bands experienced less pain, became more physically fit, and achieved a better QoL<sup>17</sup>.

### ***Health Resort Medicine and Physical Therapy***

Complications connected with osteoporosis, such as fractures, are common in the population and early identification of at-risk patients is extremely important. Early diagnosis is the best way of preventing fractures. Besides pharmaceutical treatment, therapy for osteoporosis patients should include lifestyle changes such as the cessation of harmful habits (e.g.,

smoking, alcohol abuse), an increase in physical activity, and adhering to a healthy diet. Additionally, physical therapy should be implemented to reduce pain, increase functional performance and minimize the risk of fracture. In addition to pharmaceutical treatment and physical therapy, social support and psychotherapy play a significant role, as the disease is often accompanied by depression, loneliness, and social isolation. A physical rehabilitation specialist must assess a patient's fall risk and plan a program of physical therapy and education accordingly. Comprehensive rehabilitation therapy is provided to prevent falls and fractures and to limit their consequences if they do occur. Promoting daily physical activity, raising awareness of individual risk factors, and monitoring the patient for gait and balance disorders, consequences of any falls that do occur, and frailty syndrome are important aspects in this area. Safety awareness in every day activities is particularly important.

In Poland, there is a system of health resort medicine that takes advantage of the health benefits of local climate and natural medicinal resources. Health resorts combine pharmaceutical treatment, physiotherapy, psychotherapy, and dietary interventions. The use of these multiple methods enables comprehensive therapeutic and preventive management. In health resort medicine, treatments must be repeated in prescribed cycles, and effects tend to develop over time. However, these beneficial effects typically persist longer than those resulting from pharmaceutical treatment, and adverse effects are considerably less common. In addition, health resort treatments are typically less costly and more pleasant for the patient<sup>18</sup>.

In Poland, health resorts providing osteoporosis treatments are located, e.g., in Ciechocinek, Cieplice Śląskie Zdrój (part of the town of Jelenia Góra), and Duszniki Zdrój.

Physical treatments provided in health resorts include natural therapeutic procedures (balneotherapy) and hydrotherapy, psychotherapy, kinesitherapy, and massage therapy.

Balneotherapy is one of the most important methods used in health resorts. Mineral waters are used for therapeutic baths, as well as for drinking and inhalation. Peloids, such as peat, are used for massages, wraps, baths and sitz baths. In hydrotherapy, water at a specific pressure and temperature is used. Examples of hydrotherapy treatments include: showers and jets, bubble and

whirlpool baths, aquatic massages and hydro massages. Physiotherapy uses various forms of energy, such as electrical currents, magnetic fields, light and ultrasounds<sup>19,20</sup>.

Bone mineral density can be improved with the use of low-frequency alternating magnetic fields (LFAMF). Research has demonstrated that such interventions positively affect bone healing. Some publications have confirmed improved bone mineral density in patients with osteoporosis after magnetic field therapy.

A major role in the treatment and prevention of osteoporosis is also played by light therapy and UV phototherapy, which stimulates the production of vitamin D3 in the skin. A wavelength of 280-315 nm is recommended<sup>12</sup>.

Osteoporosis rehabilitation guidelines mainly focus on the selection of appropriate kinesiotherapy exercises. Thermotherapy treatments should be avoided, as they may exacerbate the symptoms. Chronic pain in osteoporosis is alleviated by such treatments as massages, galvanic treatment, iontophoresis, diadynamic currents, interference currents, ultrasound, magnetotherapy, and – in a health resort setting – peloidotherapy (peat pulp baths) and crenotherapy (curative water drinking). Table IV lists the guidelines for these various treatments for osteoporosis.

Patients with osteoporosis require comprehensive management by a specialized rehabilitation team, physicians, physical therapists, psychologists, occupational therapists, nutritionists and others. All their interventions aim at inhibiting the progression of the disease and improving the patients' QoL. Further follow-up, population-based studies, and randomized clinical trials are warranted in this area.

### Diet

Nutritional deficiencies are a common cause of muscle dysfunction and adverse qualitative changes in bone tissue. The most dangerous deficiencies are those occurring in childhood and adolescence, during skeletal development and peak bone mass accumulation.

Normal functioning of the skeletal system is significantly affected by the intake of calcium, vitamin D3 and protein. A sufficient intake of these substances ensures that bone tissue has the required mechanical strength and in the elderly reduces the risk of falls and fractures.

The recommended daily intake of calcium and vitamin D is 1200 mg and 800 IU, respectively. These doses reduce the risk of fracture in individuals over 65 years and postmenopausal women<sup>21</sup>.

### Calcium

A balanced diet is the best way to ensure adequate calcium intake. The required calcium intake depends on age, lifestyle, sex, and physiological state, and ranges between 1000 and 1300 mg daily. Good sources of this mineral include dairy products (yogurt, cheese, buttermilk), sesame seeds, nuts, almonds, and pulses.

To increase the dietary intake of calcium, supplements with organic or inorganic compounds containing calcium ions may be used. Dietary supplements vary greatly in efficacy and absorbability, based on their content of calcium ions, their chemical form and the excipients used. The bioavailability of calcium is better when organic forms are used, e.g. gluconate, citrate or lactate. Organic calcium compounds are also present in food, and therefore the body's absorption and retention of Ca<sup>2+</sup> ions is better in the case of dietary sources. Calcium ions are only absorbed in the

**Table IV.** Role of physical therapy in osteoporosis.

Procedure	Intensity	Duration (min)	Frequency	Series	Notes
Galvanic currents	Low moderate	10-20	Daily or every other day	10-20	
Iontophoresis	Locally	20	Daily or every other day	10-20	Calcium – anode
Diadynamic currents	1-3 mA	DF – 1CP – 4	Daily or every other day	10	1-week break
Interference currents	0-10, 0-100	10-15	Daily or every other day	10-15	Alternately with diadynamic
Ultrasound	0.2 W/cm <sup>2</sup>	3-65-8	Daily or every other day	6-8 10-15	Paraffin (water, local/segmental)
Magnetotherapy	15 mT	12 × 3	Daily	60	Alternating magnetic field
Peloidotherapy	37°C	15-20	Every other day	10-15	Peat pulp bath, total or partial

presence of vitamin D (calcitriol), which is why both calcium and vitamin D intake is important for the prevention of osteoporosis<sup>14</sup>. Table V lists the adequate daily intake of calcium in adults, and Table VI – the calcium content in selected foods<sup>5,22,23</sup>.

**Vitamin D**

In Poland, vitamin D3 deficiencies are common. During the autumn and winter, supplementation is required due to insufficient synthesis of the vitamin in the skin. Deficiencies are particularly common in people with joint diseases and in the elderly. Supplementation should follow the applicable guidelines developed for the Central European population. However, the dosage should not be lower than 800-1000 IU/day in adults, as this dose reduces the risk of fracture in postmenopausal women and in individuals of both sexes aged 65 or above. Patients with osteoporosis who are found to have a low serum level of vitamin D3 require compensation with therapeutic doses. In such cases, the recommended dose may be as high as 7000 IU per day for 8-12 weeks, followed by 2000 IU per day to maintain the effect.

Vitamin D has a number of health benefits, including:

- Reduction of bone resorption,
- Improvement of bone quality,
- Reduction of fall risk due to better balance, muscle strength, joint mobility, coordination, and quality of life.

Vitamin D deficiencies result in a loss of muscle strength, grip strength, and mobility. Research shows that serum levels of vitamin D below 50 nmol/L are associated with a higher risk of balance disorders, and levels below 30 nmol/L

**Table V.** Adequate intake of calcium in adults.

Daily calcium intake – AI*	
Men and women aged 19-50 years	1000 mg
Women and men aged > 51 years	1300 mg
Pregnancy and lactation < 19 years	1300 mg
Pregnancy and lactation ≥ 19 years	1000 mg

\*Adequate intake (AI) – the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group of apparently healthy and well-nourished people that are assumed to be adequate for most in this group. This recommendation is used when the average requirement cannot be calculated.

**Table VI.** Calcium content per 100 g in selected foods.

Product	Calcium content per 100 g*
Poppy seeds	1266 mg
Sardines in oil	330 mg
Soybean seeds, dry	240 mg
Almonds	239 mg
Dried figs	203 mg
Linseeds	195 mg
Parsley leaves	193 mg
Hazelnuts	186 mg
White beans, dry	163 mg
Plain yogurt	170 mg
Cow's milk	120 mg
Low-fat cottage cheese	96 mg
Hard cheese	867 mg

– with lower muscle strength. Difficulty getting up from a chair or climbing stairs, or chronic muscular pains, are symptoms of major vitamin D deficiency.

In the context of osteoporosis in postmenopausal women, the use of vitamin D supplements has been shown to increase calcium absorption in the gut. However, it is not recommended for routine use in healthy women with normal calcidiol levels.

Small quantities of vitamin D are found in food, mainly in fat-rich animal products. Table VII lists the vitamin D content in selected foods<sup>5,24</sup>.

**Protein**

Protein is considered to be another significant factor in the pathogenesis of osteoporosis. Both an excessive and an insufficient dietary intake of protein may contribute to bone loss. Protein deficiency impairs the synthesis of collagen, which accounts for a considerable part of bone mass. It also adversely affects the synthesis of IGF-1, a growth factor necessary for normal bone tis-

**Table VII.** Vitamin D sources.

Product	Vitamin D content
Fresh eel	1200 IU/100 g
Pickled herring	480 IU/100 g
Herring in oil	808 IU/100 g
Fresh cod	40 IU/100 g
Baked salmon	540 IU/100 g
Canned sardines/tuna	200 IU/100 g
Hard cheese	7.6-28 IU/100 g
Breast milk	1.5-8 IU/100 ml
Cow's milk	0.4-1.2 IU/100 ml



sue growth in adolescents. The currently recommended protein intake is 1.2 g/kg of body weight.

Notably, the balance of animal and plant protein in one's daily diet is key in preventing osteoporosis. Excessive consumption of animal protein results in the release of phosphates and carbonates stored in bone, and with them, a certain amount of calcium. This process can lead to decreased bone mineral density. Therefore, pulses should be used as an alternative source of protein. Diets with a high ratio of animal to plant protein have been found to be associated with the highest incidence of osteoporotic fractures.

Phytoestrogens also have a demonstrated positive impact on bone tissue. In a study on a group of postmenopausal women, the consumption of soy isoflavones was positively correlated with bone mineral density. Phytoestrogens in combination with vitamin D are thought to activate osteoblasts, making them an important contributor to postmenopausal osteoporosis prevention<sup>5,25</sup>.

## Conclusions

Osteoporosis is a social issue that will continue to grow in severity along with population ageing. Due to the high incidence of osteoporotic fractures, primary and secondary prevention is essential. To curb the development of osteoporosis and counteract its consequences (including disability), a comprehensive approach to treatment is required, including pharmaceutical treatment, exercise, physical therapy, and adherence to a proper diet, with supplementation when necessary.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

### Authors' Contribution

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