



"CALCIUM: FOUNDATIONS OF HEALTH AND DISEASE PREVENTION"

Chaitrali Rodge^{1*}, Smita More¹

¹PES Modern College of Pharmacy [For Ladies], Moshi, Pune.



*Corresponding Author: Chaitrali Rodge
PES Modern College of Pharmacy [For Ladies], Moshi, Pune.

Article Received on 25/07/2025

Article Revised on 14/08/2025

Article Accepted on 04/09/2025

ABSTRACT

Calcium is a vital mineral that supports numerous physiological functions, including maintaining bone health, enabling muscle function, facilitating nerve transmission, and aiding cellular signaling. This review examines the critical aspects of calcium in human health, focusing on its extraction processes, daily dietary requirements, benefits, and the health consequences of calcium deficiency. The article explores the different methods of calcium extraction, highlighting both natural and industrial approaches. Furthermore, the recommended daily calcium intake is discussed in relation to age, gender, and life stage. A significant portion of this review is dedicated to the diseases and disorders associated with calcium deficiency, such as osteoporosis, rickets, hypocalcaemia, and muscle spasms, along with their diagnosis and treatment options. Finally, the article underscores the importance of maintaining adequate calcium levels through diet, supplementation, and lifestyle modifications to prevent calcium deficiency-related health issues.

KEYWORDS: Calcium, human health, dietary requirements, cellular signalling.

INTRODUCTION

History: The story of calcium began in 1808 when Humphry Davy first isolated the element using electrochemical methods, extracting it from alkaline earth materials. However, it wasn't until 1883 that Sydney Ringer demonstrated its biological importance. Ringer showed that frog hearts required calcium in their bathing solution to continue beating, a discovery that opened up extensive research into calcium's role in molecular, cellular, and organismal functions.

By the end of the 19th century, various essential functions of calcium were identified, including its involvement in egg fertilization, tissue development (such as bone formation), nerve impulse conduction to muscles, cell adhesion, and even plant growth. The 20th century saw a continued focus on uncovering calcium's cellular functions, highlighting its significance in both normal physiological processes and various disease states.^[1]

Calcium: Calcium is a crucial inorganic element in both animals and humans, playing a vital role in various metabolic processes throughout life. It is essential for functions such as signal transmission, muscle contraction, and bone development, highlighting its integral involvement in these physiological activities.^[2]

Calcium is the most abundant stored nutrient in the human body, with more than 99% of it (about 1.2-1.4 kg) stored in the bones and teeth. Only a small fraction, less than 1%, is present in extracellular serum calcium. When adults take in calcium through food or supplements, the typical absorption rate is about 30%, though this can vary greatly due to various factors.^[3]

BENEFITS OF CALCIUM

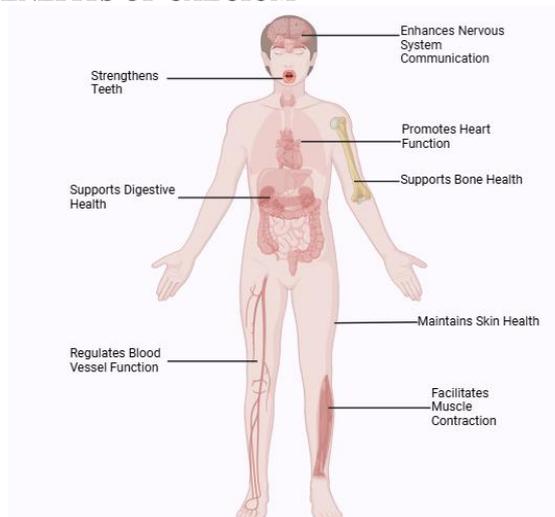


Fig. 1: Benefits of Calcium.

1. Supports Bone Health: Calcium plays a vital role in the composition of bone tissue, helping to maintain its strength and structure. Adequate calcium consumption is essential for reducing the risk of osteoporosis and fractures, especially in older individuals.^[4]
2. Promotes Heart Function: Calcium is vital for maintaining a regular heart rhythm. It aids in the contraction of heart muscles, ensuring efficient blood circulation throughout the body.^[5]
3. Facilitates Muscle Contraction: Calcium plays an essential role in the contraction of muscles. When a muscle is stimulated by a nerve, calcium ions are released, allowing the proteins actin and myosin to interact and produce movement.^[6]
4. Enhances Nervous System Communication: In the nervous system, calcium is critical for transmitting signals between neurons. It is involved in the release of neurotransmitters, facilitating effective communication within the brain and across the body.^[7]
5. Strengthens Teeth: Calcium is essential for maintaining the strength and structure of teeth. It helps prevent dental decay and supports the overall health of dental tissues.^[8]
6. Aids Blood Clotting: Calcium is essential in the blood coagulation process. During an injury, it activates clotting factors, which help control bleeding and promote healing.^[9]
7. Regulates Hormonal Secretion: Calcium is important for the release of various hormones and enzymes. It plays a significant role in regulating numerous physiological processes, including metabolism and cellular activities.^[10]
8. Maintains Skin Health: Calcium contributes to the production and repair of skin cells. It helps preserve the skin's barrier function, promoting hydration and overall skin integrity.^[11]
9. Supports Digestive Health: Calcium is beneficial in the digestive process, enhancing the secretion of digestive enzymes and maintaining a healthy gastrointestinal tract.^[12]
10. Regulates Blood Vessel Function: Calcium helps regulate the contraction and relaxation of blood vessels, playing a key role in supporting healthy blood pressure and ensuring proper circulation throughout the body.^[13]

Table 1: Daily Recommended Calcium Intake.^[14]

Age/Gender	Calcium (mg/day)
Children/Adolescents	
0-3 years old	200-700
4-18 years old	1000-1300
Female	
Pregnancy/lactation (14-18 years old)	1300
Pregnancy/lactation (19-50 years old)	1000
Postmenopausal or ≥ 51 years old	1200
Male	
19-70 years old	1000
≥ 71 years old	1200

Source of calcium: Calcium is primarily found in a variety of foods, with dairy products being among the richest sources. Other significant contributors include certain leafy greens, nuts, seeds, and fortified foods. Understanding these sources is crucial for ensuring adequate calcium intake, especially for those with dietary restrictions or lower consumption of dairy.^[15]

Table 2: Source of Calcium.^[16]

Food Source	Calcium Content (mg/100g)	Notes
Dairy Products		
Hard Cheese	~1000	High calcium source
Milk, Yogurt	100-180	Varies by type
Cereals	30	Fortified cereals can reach up to 180 mg
Nuts and Seeds		
Almonds, Sesame, Chia	250-600	High calcium content
Vegetables		
Kale, Broccoli, Watercress	100-150	Rich in calcium

Table No. 3: Dietary Patterns by Region.^[17]

Region	Dairy Contribution to Total Calcium Intake	Other Key Sources
Developed Countries	~14%	Dairy products (e.g., milk, cheese)
United States	~72%	Significant dairy intake
Holland	~58%	Significant dairy intake
Developing Countries	~4%	Higher reliance on non-animal foods
China	~7%	Vegetables (30.2%), legumes (16.7%)

ISOLATION OF CALCIUM: Isolation is a technique used in organic chemistry to extract specific compounds from a more complex matrix. There exist several

techniques for the isolation of organic molecules.^[18] In the process of researching and producing natural products, the most crucial, challenging, and time-

consuming phase is the isolation of chemicals from natural sources. The extraction process comes first, and then there are several separating procedures. The first stage in obtaining crude extract from natural sources is extraction. Other techniques for isolation include distillation, sublimation, and crystallization.^[18]

Extraction: Extraction is a vital first step in medicinal plant research, often neglected, which can lead to inefficiencies. Traditional methods like solvent extraction typically rely on heat and agitation but can be time-consuming and risk damaging sensitive compounds. Given that plants can contain thousands of secondary metabolites, more efficient extraction techniques are urgently needed.^[19] Recent innovations like supercritical fluid extraction (SCFE), pressurized solvent extraction (PSE), and microwave-assisted extraction (MAE) offer quicker processing, lower solvent consumption, and better preservation of sensitive compounds, which could significantly improve the quality of herbal medicines worldwide.^[20] The extraction process consists of permeating the solid matrix with a solvent, dissolving the target compounds, allowing them to diffuse out, and then collecting the extracts. Extraction efficiency is affected by various factors such as the solvent's properties, the raw material's particle size, the solvent-to-solid ratio, temperature, and extraction time. Traditional extraction techniques, like maceration, percolation, Soxhlet, and decoction, require large amounts of solvent and long extraction durations.^[21]

Soxhlet extraction: The Soxhlet extraction method operates on the principles of reflux and siphoning, allowing for the continuous extraction of compounds from herbs with fresh solvent. This technique combines the benefits of both reflux extraction and percolation.^[22] Compared to maceration or percolation, Soxhlet extraction offers automated, continuous extraction with high efficiency. However, the high temperatures and extended extraction times involved increase the risk of thermal degradation.^[21]

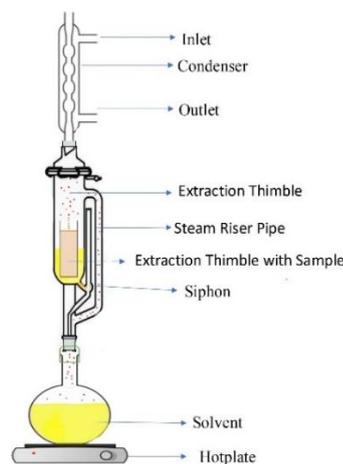


Fig. 2: Soxhlet extraction.

Percolation: Percolation is a more effective extraction method than maceration due to its continuous nature. In this process, the solvent that becomes saturated with solute is regularly replaced with fresh solvent, ensuring a more efficient extraction of desired compounds. This constant flow enhances the overall extraction yield and allows for better utilization of the solvent, making percolation a preferred technique in many applications.^[23]

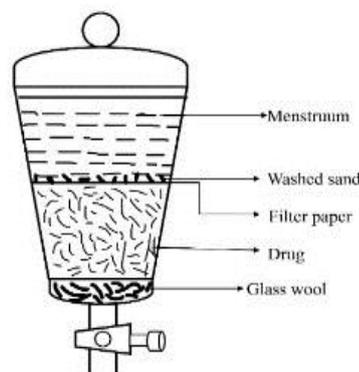
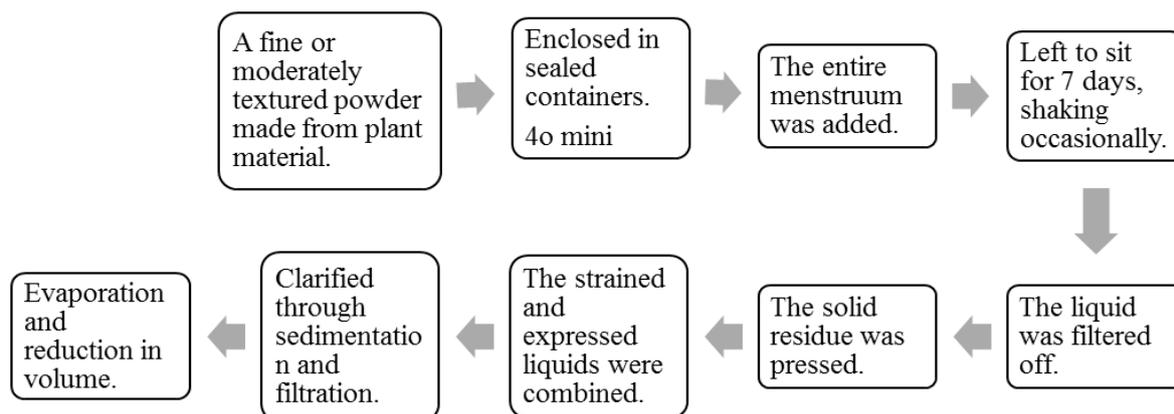


Fig. 3: percolation.

Maceration: Maceration is a simple extraction technique, but it comes with certain drawbacks, including extended extraction times and relatively low efficiency. Despite these limitations, it is effective for extracting thermolabile compounds, as the gentle process minimizes the risk of thermal degradation. This method is particularly suitable for sensitive materials that require careful handling during extraction.^[24]



Decoction: Decoction extracts typically include various water-soluble impurities. This method is ineffective for extracting volatile or thermolabile compounds, as the elevated temperatures can result in the degradation or loss of these sensitive substances. Therefore, while

decoction can successfully extract specific soluble constituents, it is not suitable for all compound types, especially those that are fragile or susceptible to heat damage.^[25]

DIFFERENT FORMS OF CALCIUM

Table 4: Different Forms of Calcium.

Forms of Calcium	Absorption Rate	Tolerability	Common Uses
Calcium Carbonate	Moderate to good; best absorbed with food due to reliance on stomach acid.	Generally well-tolerated, may cause gas/bloating.	General supplementation; cost-effective option for those without digestive issues. ^[26]
Calcium Citrate	High; can be absorbed well on an empty stomach.	Excellent tolerability, less gastrointestinal discomfort	Recommended for individuals with lower stomach acid, such as older adults. ^[27]
Calcium Gluconate	Lower absorption	Generally well-accepted, though some individuals may experience mild side effects.	Primarily used in medical settings for rapid calcium delivery, not common for daily supplementation. ^[28]
Calcium Lactate	Moderate; can be absorbed with or without food	Generally well-tolerated, but lower elemental calcium means larger doses needed.	Used as a dietary supplement and in food fortification; can be suitable for those with digestive issues. ^[29]
Calcium Phosphate	Good; often absorbed well with food.	Well-tolerated, may cause mild gastrointestinal discomfort	Used for bone health; also provides phosphate, beneficial for bone mineralization. ^[29]
Coral Calcium	Varies; can have moderate absorption rates, depending on the source.	Generally well-tolerated; marketed as a natural option.	Promoted for general health and wellness: contains trace minerals. ^[29]
Calcium Acetate	Moderate; effective in managing phosphate levels in the body.	Generally well tolerated; primarily used in specific medical conditions.	Used primarily in patients with kidney disease to control phosphate levels during dialysis. ^[29]

DISEASE CAUSED DUE TO DEFICIENCY OF CALCIUM

Calcium is a vital mineral involved in several physiological functions, such as supporting bone health, muscle activity, and nerve signal transmission. Insufficient calcium levels can precipitate a variety of health conditions, each associated with distinct pathophysiological mechanisms and clinical implications. This section aims to delineate the diseases commonly linked to calcium deficiency, elucidate their treatment modalities, and underscore the significance of adequate calcium intake in promoting overall health and

preventing adverse health outcomes. By exploring these aspects, a comprehensive understanding of the implications of calcium deficiency on human health can be achieved.^[30]

Hypocalcaemia: Hypocalcaemia is a medical condition defined by abnormally low levels of calcium in the bloodstream. While it can arise from a deficiency in calcium intake, the causes of hypocalcaemia are multifaceted and often interconnected with various physiological and pathological factors.

Category	Details
Causes	<p>Dietary Deficiency: Insufficient intake of calcium-rich foods, like dairy, can result in hypocalcaemia by depleting the body's calcium stores over time.</p> <p>Vitamin D Deficiency: Vitamin D is crucial for calcium absorption. A lack of it, especially in individuals with limited sunlight exposure, can impair calcium absorption, contributing to low calcium levels.</p> <p>Hormonal Imbalances: Calcium regulation depends on hormones like parathyroid hormone (PTH) and calcitonin. Disorders such as hypoparathyroidism reduce PTH secretion, while pseudohypoparathyroidism affects the body's response to PTH, disrupting calcium balance.</p> <p>Renal Dysfunction: Kidney diseases can increase calcium loss in urine. Chronic kidney disease impairs phosphorus management and vitamin D synthesis, both essential for calcium regulation.^[31]</p>
Symptoms	<p>Symptoms can vary in severity. Mild cases may be asymptomatic, while more severe deficiencies can cause muscle cramps, spasms, and fatigue. Severe cases may lead to neurological symptoms like seizures, hallucinations, and tingling in extremities, and prolonged cases can result in osteopenia or osteoporosis.^[32]</p>
Diagnosis	<p>Blood Testing: Diagnosis typically begins with a blood test to measure serum calcium levels, which helps determine if levels are abnormally low.</p> <p>Additional Assessments: Tests for parathyroid hormone (PTH) and vitamin D levels are often conducted to identify hormonal imbalances or deficiencies contributing to low calcium levels, aiding accurate diagnosis and treatment planning.</p> <p>Normal Range: Serum calcium levels typically fall within the normal range of 2.1 to 2.6 mmol/L. Levels outside this range warrant further evaluation to uncover underlying causes.^[32]</p>
Treatment	<p>Identifying Causes: starts with assessing dietary intake, medical history, and health conditions to identify underlying causes of hypocalcemia, essential for creating an effective treatment plan.</p> <p>Supplementation: After identifying causes, healthcare providers may recommend calcium and vitamin D supplements to restore calcium levels and enhance dietary absorption. Regular monitoring may be necessary to adjust dosages.</p> <p>Dietary Modifications: Patients are advised to consume more calcium-rich foods, including dairy products, leafy vegetables, and fortified cereals, to enhance calcium levels and support overall health.</p> <p>Managing Related Conditions: Addressing other medical conditions that contribute to calcium loss is crucial for effective treatment. Managing issues like kidney disease or hormonal disorders can help reduce the risk of recurring hypocalcemia.^[33]</p>

Muscle Problems: Calcium deficiency can arise from several factors. Inadequate dietary intake is a common cause, especially in individuals with limited access to calcium-rich foods or those on restrictive diets. Medical conditions such as celiac disease and Crohn's disease can impair calcium absorption from the digestive tract.

Hormonal imbalances, particularly involving parathyroid hormone (PTH) and vitamin D, can also lower calcium levels. Age plays a role as well, as older adults often experience decreased dietary intake and reduced calcium absorption, increasing their risk of deficiency.^[34]

Category	Details
Symptoms	<p>Muscle Cramps and Spasms: Sudden, involuntary contractions that can occur during rest or physical activity.</p> <p>Tetany: Extended muscle contractions characterized by stiffness and twitching, affecting both skeletal and smooth muscles.</p> <p>Muscle Weakness: A general sense of weakness that can hinder physical performance and daily activities.</p> <p>Fatigue: A persistent feeling of tiredness, especially noticeable after exertion.</p> <p>Numbness and Tingling: Sensations often felt in the extremities, which may accompany muscle spasms.^[35]</p>
Diagnosis	<p>Clinical Evaluation: Assessment of symptoms and medical history by healthcare providers.</p> <p>Laboratory Tests: Blood tests to measure serum calcium levels, parathyroid hormone levels, and vitamin D status.</p> <p>Advanced Methods: Techniques like dual-energy X-ray absorptiometry (DXA) scans to evaluate bone density, providing insights into calcium status and associated risks.^[36]</p>
Treatment	<p>Calcium Supplements: The primary treatment for calcium deficiency is the use of calcium supplements, either in the form of pills or liquids, under the guidance of a healthcare provider.</p> <p>Calcium-Rich Diet: Increasing the intake of calcium-rich foods such as dairy products, leafy greens, fortified cereals, and nuts can help restore calcium levels.</p> <p>Vitamin D: Adequate Vitamin D levels are necessary for proper calcium absorption. In some cases, Vitamin D supplements may also be prescribed.^[37]</p>

Rickets: Rickets is a condition affecting bone growth in children, caused by deficiencies in calcium, vitamin D, or phosphate. It leads to defective mineralization, poor bone growth, and skeletal deformities such as bow-legs

and knock-knees. Calcium and phosphorus shortages, which are essential for bone formation, are typically the main causes of this condition.^[38]

Category	
Causes	<p>Calcium Deficiency: A lack of calcium in the diet can weaken bones, as calcium is essential for proper bone mineralization.</p> <p>Vitamin D Deficiency: Vitamin D is crucial for the absorption of calcium in the intestines. Insufficient levels of vitamin D can lead to low calcium levels, contributing to the development of rickets. This deficiency may arise from inadequate sun exposure, poor dietary habits, or malabsorption issues.</p> <p>Phosphate Deficiency: Low levels of phosphate can also lead to rickets. Phosphate is important for bone health, and its deficiency can disrupt the process of bone mineralization.^[39]</p>
Symptoms	<p>Bone Pain or Tenderness: Children may feel pain or sensitivity in their bones, particularly in the legs and spine. This can be a result of calcium deficiency, which impacts bone development and strength.</p> <p>Muscle Weakness: Weakness in the muscles can affect a child's physical activity and overall strength.</p> <p>Skeletal Deformities: Conditions such as bowed legs, thickened wrists and ankles, and other deformities can occur due to weakened bones.</p> <p>Dental Problems: Deficiencies may lead to poor enamel formation, resulting in dental issues.^[40]</p>
Diagnosis	<p>Medical History and Physical Examination: Healthcare providers assess symptoms and review the child's growth patterns.</p> <p>Blood Tests: Blood tests are conducted to measure levels of calcium, phosphate, vitamin D, and parathyroid hormone, helping to identify any deficiencies or imbalances.</p> <p>X-rays: Imaging studies can reveal bone deformities and characteristic changes associated with rickets.^[41]</p>
Treatment	<p>Dietary Adjustments: Enhancing the diet with calcium and vitamin D-rich foods like dairy, leafy vegetables, fatty fish, and fortified products is crucial for recovery.</p> <p>Supplements: Calcium and vitamin D supplements might be recommended to correct deficiencies and promote bone health.</p> <p>Sunlight Exposure: Safe sun exposure can help increase vitamin D levels, though precautions should be taken to protect the skin from harm.</p> <p>Physical Therapy: In certain cases, physical therapy may be suggested to improve strength and mobility, especially when skeletal deformities are present.^[42]</p>

Severe Premenstrual Syndrome (PMS): Premenstrual Syndrome (PMS) involves physical and emotional symptoms occurring 1-2 weeks before menstruation, often affecting daily life. Nutritional deficiencies, like low calcium, may contribute. PMS is common among women of reproductive age worldwide.^[43] During the luteal phase (7-14 days before menstruation), most women experience PMS, with physical symptoms like

bloating, weight gain, headaches, nasal congestion, and tingling, along with emotional issues such as irritability, anxiety, and depression.^[44] PMS symptoms vary among individuals, with physical, emotional, and behavioural causes requiring separate assessment. Sociocultural factors and diagnostic methods influence its prevalence, which is estimated at 30-40%.^[45]

Category	Details
Causes	<p>Hormonal Fluctuations: PMS symptoms are largely driven by hormonal changes throughout the menstrual cycle. Calcium helps regulate neurotransmitters and hormones; therefore, low calcium levels can worsen mood swings and emotional symptoms associated with PMS.</p> <p>Muscle Cramping: Calcium deficiency can lead to muscle cramps, which are commonly experienced during PMS. Insufficient calcium may increase muscle tension and discomfort during menstruation.^[46]</p> <p>Bone and Joint Pain: Low calcium levels can negatively impact bone health, leading to pain or discomfort that may occur alongside menstrual symptoms.</p> <p>Mood Regulation: Calcium affects the release of neurotransmitters like serotonin. Low calcium levels might be associated with mood disturbances, irritability, and anxiety frequently experienced during PMS.^[47]</p>
Symptoms	<p>Emotional Symptoms: Intense mood swings, irritability, anxiety, and feelings of depression.</p> <p>Physical Symptoms: Bloating, breast tenderness, headaches, and muscle cramps.</p> <p>Fatigue: Increased tiredness and difficulties with concentration.</p> <p>Changes in Sleep Patterns: Insomnia or excessive sleep, often tied to emotional distress.^[48]</p>
Diagnosis	<p>Medical History and Symptom Diary: Keeping track of symptoms across several menstrual cycles helps healthcare providers assess the severity and pattern of PMS.</p> <p>Physical Examination: A healthcare provider may conduct a physical exam to rule out other potential</p>

	conditions. Blood Tests: These tests can measure calcium levels, hormone levels, and other markers to identify any deficiencies or imbalances. ^[49]
Treatment	Dietary Changes: Increasing the intake of calcium-rich foods, such as dairy products, leafy greens, nuts, and fortified foods, can help reduce symptoms. Calcium and Vitamin D Supplements: If dietary intake is inadequate, supplements might be recommended to ensure sufficient calcium levels and support hormonal balance. Lifestyle Modifications: Regular exercise, stress management techniques (like yoga or meditation), and adequate sleep can help alleviate PMS symptoms. Medications: In some instances, healthcare providers may suggest hormonal treatments, antidepressants, or other medications to manage severe PMS symptoms effectively. ^[50]

Hormonal Imbalance: Calcium deficiency can cause hormonal imbalances, leading to various health issues. For example, low calcium levels trigger an increase in parathyroid hormone (PTH) secretion, while reducing the effectiveness of calcitonin, which can worsen the situation. Additionally, insufficient calcium impairs the

activation of vitamin D, crucial for calcium absorption in the intestines. Understanding the relationship between calcium deficiency and hormonal regulation is key to managing health problems linked to low calcium levels.^[51]

Category	Details
Causes	PTH Regulation: Parathyroid hormone regulates calcium levels by releasing calcium from bones, increasing absorption, and reducing urinary loss when levels drop. Chronic low calcium can cause elevated PTH, leading to bone loss and metabolic complications. ^[51] Vitamin D Interaction: Calcium and vitamin D work together to maintain calcium balance. A deficiency in vitamin D can worsen calcium deficiency and disrupt the hormonal mechanisms required for proper calcium absorption and usage. ^[52] Impact on Other Hormones: Low calcium levels can also affect the secretion of other hormones, such as calcitonin, produced by the thyroid gland. Calcitonin helps reduce blood calcium levels, and an imbalance can disrupt overall calcium metabolism. ^[53]
Symptoms	Fatigue: Ongoing tiredness or a lack of energy due to metabolic disturbances. Mood Changes: Irritability, anxiety, or depression resulting from altered hormone levels. Bone Pain or Weakness: An increased risk of fractures or chronic pain due to loss of bone density. Menstrual Irregularities: In women, hormonal imbalances can disrupt menstrual cycles, leading to irregular periods. ^[54]
Diagnosis	Blood Tests: To measure serum calcium, PTH, and vitamin D levels, assessing calcium status and associated hormonal functions. Hormonal Panel: Evaluating other affected hormones, such as thyroid or sex hormones. Medical History and Physical Examination: Discussing symptoms and relevant medical history with a healthcare provider
Treatment	Dietary Changes: Increasing the intake of calcium-rich foods (such as dairy products, leafy greens, and fish with bones) can help restore calcium levels. Supplementation: Calcium and vitamin D supplements may be suggested to address deficiencies and support hormonal balance. Monitoring and Management: Regular follow-ups with healthcare professionals are important to monitor hormone levels and adjust treatments as needed. Addressing Underlying Conditions: If other health issues contribute to hormonal imbalances, appropriate treatment is essential. ^[55]

Heart Disease: Calcium is vital for cardiovascular health, and a deficiency can impact heart disease. It plays a key role in muscle contraction, metabolism, and regulating cardiac rhythm. Due to its involvement in various physiological processes, heart disease cannot be

linked to a single cause when considering calcium metabolism. Instead, calcium's role is important in several heart conditions, such as ischemic heart disease, heart failure, and arrhythmias.^[56]

Category	Details
Causes	Impaired Muscle Function: Calcium is vital for cardiac muscle function. A deficiency can impair heart function, increasing heart disease risk. ^[57] Hypertension: Low calcium intake may contribute to high blood pressure by disrupting vascular contraction and dilation, a key factor in heart disease. ^[58] Hormonal Effects: Calcium deficiency can affect hormone secretion, particularly parathyroid hormone

	(PTH), which influences calcium levels and cardiovascular health. ^[59] Bone Health: Chronic calcium deficiency can cause osteoporosis and reduced bone density, potentially increasing cardiovascular risk through mechanisms like inflammation and hormonal changes. ^[60]
Symptoms	Chest Pain or Discomfort: Angina can occur due to compromised heart function. Shortness of Breath: Difficulty breathing during exertion or even at rest may arise. Fatigue: A constant sense of tiredness can be linked to poor heart health. ^[61] Irregular Heartbeat: Arrhythmias can occur due to electrolyte imbalances, including calcium. ^[62]
Diagnosis	Medical History and Physical Examination: Healthcare providers assess symptoms and risk factors. Blood Tests: These can measure serum calcium levels, along with other electrolytes, to identify deficiencies. Electrocardiogram (ECG): This test evaluates heart rhythm and can detect irregularities. ^[63] Imaging Studies: Echocardiograms or other imaging techniques may be used to assess heart structure and function. ^[64]
Treatment	Dietary Improvements: Increasing the intake of calcium-rich foods, such as dairy products, leafy greens, fish with bones, and fortified foods, can help restore calcium levels. Calcium and Vitamin D Supplements: If dietary changes are insufficient, supplements may be necessary to address deficiencies and support cardiovascular health. Blood Pressure Management: If hypertension is present, lifestyle modifications such as a heart-healthy diet (e.g., the DASH diet), regular exercise, and stress management are crucial. Cardiovascular Care: Depending on the severity of heart disease, additional treatments such as medications or interventions may be required to manage symptoms and reduce cardiovascular risk. ^[65]

Dental Problem: Calcium deficiency can significantly impact dental health, leading to various issues.

Category	Details
Causes	Weakened Tooth Structure: Calcium is vital for maintaining the integrity of tooth enamel. A deficiency can weaken the enamel, making teeth more vulnerable to decay. Increased Risk of Cavities: Compromised enamel allows bacteria to penetrate more easily, resulting in higher rates of dental caries (cavities). Gum Disease: Calcium helps maintain healthy gums. A deficiency may contribute to periodontal disease, characterized by inflammation and infection of gum tissues, potentially leading to tooth loss. Delayed Tooth Development: In children, insufficient calcium intake can hinder proper tooth development, leading to misalignment or other dental issues. ^[66]
Symptoms	Tooth Sensitivity: Increased sensitivity to hot, cold, or sweet stimuli due to weakened enamel. Visible Decay: Dark spots or cavities on teeth. Gum Issues: Swollen, red, or bleeding gums, indicating possible gum disease. Loose Teeth: Advanced gum disease can lead to tooth mobility or loss. ^[67]
Diagnosis	Diagnosis typically involves a dental examination, where the dentist assesses the condition of the teeth and gums. X-rays may be used to evaluate decay and bone density around the teeth. A thorough medical history and dietary assessment can also help identify calcium deficiency. ^[68]
Treatment	Dietary Improvements: Increasing the intake of calcium-rich foods, such as dairy products, leafy greens, and fortified foods, can help strengthen teeth and bones. Dental Interventions: Treating existing dental issues may involve fillings for cavities, professional cleanings for gum disease, or other restorative procedures. Calcium and Vitamin D Supplements: If dietary changes are insufficient, supplements may be recommended to restore proper calcium levels. Oral Hygiene Practices: Emphasizing good oral hygiene—brushing twice daily, flossing, and regular dental check-ups—can help prevent further dental problems. ^[69]

Osteoporosis: Osteoporosis is a condition marked by a considerable reduction in bone density and strength, making bones more prone to fractures. It occurs when

there is an imbalance between bone breakdown and bone building, often influenced by factors like aging, hormonal changes, poor nutrition, and lifestyle habits.^[70]

Category	Details
Causes	Hormonal Changes: Declining estrogen in women (post-menopause) and reduced testosterone in men can lead to faster bone loss. Age: Bone density decreases with age, increasing osteoporosis risk. Nutritional Deficiencies: Lack of calcium and vitamin D weakens bones. Lifestyle Factors: Inactivity, smoking, and excessive alcohol harm bone health. Medical Conditions: Chronic illnesses like rheumatoid arthritis and gastrointestinal disorders affect bone

	<p>density.</p> <p>Medications: Long-term use of medications such as corticosteroids can reduce bone density.</p> <p>Genetics: A family history of osteoporosis or fractures increases personal risk.^[71]</p>
Symptoms	<p>Fractures: Fractures are the most common and serious symptom of osteoporosis. These breaks can happen in the hip, spine, or wrist with minimal force, such as a fall or even a simple action like bending over. Such fractures can lead to severe pain and prolonged recovery times.</p> <p>Back Pain: Another common symptom is back pain, often stemming from fractured or collapsed vertebrae in the spine. This pain can range from mild discomfort to debilitating agony, impacting daily activities and mobility.</p> <p>Stooped Posture: A noticeable stooped posture, commonly referred to as "kyphosis," can develop. This change in posture not only alters physical appearance but can also contribute to emotional distress and a diminished sense of well-being.</p> <p>Weak Grip Strength: Weak grip strength may be observed, indicating overall bone health deterioration. This can affect the ability to perform everyday tasks, such as opening jars or holding objects securely.</p> <p>Difficulty with Balance: Many individuals with osteoporosis may face difficulty with balance, increasing the risk of falls. This instability is particularly concerning, as falls can lead to further fractures and complications.^[72]</p>
Diagnosis	<p>Bone Density Test (DEXA Scan): The primary method for diagnosing osteoporosis is the DEXA scan, which measures bone mineral density (BMD) in the hip and spine. This painless test assesses bone strength, with lower BMD indicating a higher fracture risk.^[73]</p> <p>Physical Examination: A physical exam evaluates posture, height, and visible signs of bone loss, such as stooped posture, helping to identify balance and stability concerns.</p> <p>Blood Tests: While not conclusive for osteoporosis, blood tests can reveal conditions contributing to bone loss. These may include calcium, vitamin D, thyroid hormones, and bone metabolism markers.^[74]</p> <p>Fracture Risk Assessment Tools: Tools like the FRAX score estimate the 10-year probability of major osteoporotic fractures using clinical risk factors and bone density, aiding in treatment decisions.^[75]</p>
Treatment	<p>Medications: Bisphosphonates (e.g., alendronate, risedronate, zoledronic acid) slow bone loss, improve density, and reduce fracture risk. Estrogen therapy helps maintain bone density but carries cardiovascular risks, while selective estrogen receptor modulators (SERMs) like raloxifene offer similar benefits with fewer risks. Teriparatide, a parathyroid hormone therapy, promotes bone growth and is recommended for those at high fracture risk. Denosumab (Prolia), an injection given every six months, inhibits bone resorption to maintain bone density. Calcitonin, available as a nasal spray or injection, alleviates pain from fractures and reduces bone loss. RANKL inhibitors are used for postmenopausal women and high-risk men, especially those undergoing cancer treatments.^[76]</p> <p>Nutritional Support: Adequate calcium (1,000 to 1,200 mg daily) and vitamin D (800 to 1,000 IU) are vital for bone health. Sources include dairy, leafy greens, fortified foods, and sunlight. Supplements may be necessary for those with limited sun exposure.^[77]</p> <p>Lifestyle Modifications: A nutrient-rich diet focusing on calcium, vitamin D, magnesium, and potassium is crucial. Regular weight-bearing exercises (walking, dancing, jogging) and strength training enhance bone density. Balance and flexibility exercises, like tai chi and yoga, help prevent falls.^[78]</p>

CONCLUSION

Calcium is indispensable for maintaining overall health, particularly in the context of bone integrity, muscular function, and metabolic regulation. Adequate calcium intake, achieved through dietary sources or supplementation, is vital for preventing calcium deficiency-related diseases. The review highlights the diverse methods of calcium extraction, with industrial methods offering large-scale production to meet global demands. The daily recommended intake varies by age and gender, emphasizing the need for individualized approaches in dietary planning. Diseases like osteoporosis, rickets, and hypocalcaemia, caused by inadequate calcium levels, can significantly impair quality of life if not properly managed. Early diagnosis and appropriate treatment, including calcium-rich diets, supplementation, and in some cases, pharmacological interventions, are essential for mitigating the adverse effects of deficiency. As the global prevalence of calcium

deficiency remains a concern, public health efforts aimed at improving calcium intake through education, fortification, and better access to resources are crucial for promoting long-term health and well-being.

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to Dr. Smita More, my esteemed guide, for her constant guidance, encouragement, and invaluable support throughout the preparation of this review article. Her insightful suggestions and constructive feedback helped shape the article into its present form.

I am also thankful to PES Modern College of Pharmacy (For Ladies), Moshi, Pune, for providing me with the resources and a conducive environment to pursue this work. The institution has been a constant source of inspiration and learning.

Lastly, I would like to extend my gratitude to all those who contributed directly or indirectly to the successful completion of this article.

REFERENCE

- Jaiswal JK. Calcium—how and why?. *Journal of biosciences*, 2001 Sep; 26: 357-63.
- Dai J, Tao L, Shi C, et al. Fermentation Improves Calcium Bioavailability in *Moringa oleifera* leaves and Prevents Bone Loss in Calcium-deficient Rats. *Food Sci Nutr.*, 2020; 8: 3692–3703.
- Beto JA. The Role of Calcium in Human Aging. *Clin Nutr Res.*, 2015 Jan; 4(1): 1-8.
- Arnaud CD, Sanchez SD. The role of calcium in osteoporosis. NASA. Lyndon B. Johnson Space Center, Spacelab Life Sciences 1: Reprints of Background Life Sciences Publications. 1991 May 1.
- Rasmussen H. The cycling of calcium as an intracellular messenger. *Scientific American*, 1989 Oct 1; 261(4): 66-73.
- Berchtold MW, Brinkmeier H, Muntener M. Calcium ion in skeletal muscle: its crucial role for muscle function, plasticity, and disease. *Physiological reviews*, 2000 Jul 1; 80(3): 1215-65.
- Teleanu RI, Niculescu AG, Roza E, Vladăcenco O, Grumezescu AM, Teleanu DM. Neurotransmitters—key factors in neurological and neurodegenerative disorders of the central nervous system. *International journal of molecular sciences*, 2022 May 25; 23(11): 5954.
- Dorozhkin SV. Calcium orthophosphates. *Journal of materials science*, 2007 Feb; 42(4): 1061-95.
- Periyah MH, Halim AS, Saad AZ. Mechanism action of platelets and crucial blood coagulation pathways in hemostasis. *International journal of hematology-oncology and stem cell research*, 2017 Oct 10; 11(4): 319.
- Rosol TJ, Capen CC. Calcium-regulating hormones and diseases of abnormal mineral (calcium, phosphorus, magnesium) metabolism. In *Clinical biochemistry of domestic animals*, 1997 Jan 1; (pp. 619-702).
- Verdier-Sévrain S, Bonté F. Skin hydration: a review on its molecular mechanisms. *Journal of cosmetic dermatology*, 2007 Jun; 6(2): 75-82.
- Theobald HE. Dietary calcium and health. *Nutrition Bulletin*, 2005 Sep; 30(3): 237-77.
- Sheng Y, Zhu L. The crosstalk between autonomic nervous system and blood vessels. *International journal of physiology, pathophysiology and pharmacology*, 2018; 10(1): 17.
- International Osteoporosis Foundation. 2014. Osteoporosis and musculoskeletal disorders – Osteoporosis – Prevention – Calcium – See our comprehensive of calcium-rich foods.
- Cormick G, Belizán JM. Calcium intake and health. *Nutrients*, 2019 Jul 15; 11(7): 1606.
- Raw P. Composition of Foods Raw, Processed, Prepared USDA National Nutrient Database for Standard Reference, Release 28 (2015) Documentation and User Guide. United States. 2015 Sep.
- Silanikove, N.; Leitner, G.; Merin, U. The interrelationships between lactose intolerance and the modern dairy industry: Global perspectives in evolutionary and historical backgrounds. *Nutrients*, 2015; 7: 7312–7331.
- Daf AN, et al. Isolation Evaluation and Estimation of Calcium Citrate from Herbal Source. *Int J Pharmacogn Chinese Med.*, 2023, 7(2): 000257.
- W. Xiao, F. Lei, Z. Hengqiang, and L. Xiaojing, in *Natural Product Extraction: Principles and Applications*, ed. M. A. Rostagno and J. M. Prado, The Royal Society of Chemistry, 2013; 314-362.
- V. Mandal, Mohan, Y., and Hemalatha, S., “Microwave Assisted Extraction-An Innovative and Promising Extraction Tool for Medicinal Plant Research”, *Pharmacognosy Reviews*, 1(1): 7-18, 2007.
- Porwal V, Singh P, Gurjar D. A comprehensive study on different methods of extraction from guajava leaves for curing various health problem. *IJERA*, 2012 Nov; 2(6): 490-6.
- Zhang QW, Lin LG, Ye WC. Techniques for extraction and isolation of natural products: A comprehensive review. *Chinese medicine*, 2018 Dec; 13: 1-26.
- Naviglio D, Scarano P, Ciaravolo M, Gallo M. Rapid Solid-Liquid Dynamic Extraction (RSLDE): A powerful and greener alternative to the latest solid-liquid extraction techniques. *Foods*, 2019 Jul 5; 8(7): 245.
- Azwanida NN. A review on the extraction methods use in medicinal plants, principle, strength and limitation. *Med aromat plants*, 2015 Jul 6; 4(196): 2167-0412.
- Nafiu MO, Hamid AA, Muritala HF, Adeyemi SB. Preparation, standardization, and quality control of medicinal plants in Africa. *Medicinal spices and vegetables from Africa*, 2017 Jan 1: 171-204.
- Morse JW, Arvidson RS, Lüttge A. Calcium carbonate formation and dissolution. *Chemical reviews*, 2007 Feb 14; 107(2): 342-81.
- Harvey JA, Zobitz MM, Pak CY. Dose dependency of calcium absorption: a comparison of calcium carbonate and calcium citrate. *Journal of Bone and Mineral Research*, 1988 Jun 1; 3(3): 253-8.
- Agus ZS, Wasserstein A, Goldfarb S. Disorders of calcium and magnesium homeostasis. *The American Journal of Medicine*, 1982 Mar 1; 72(3): 473-88.
- Trailokya A, Srivastava A, Bhole M, Zalte N. Calcium and calcium salts. *Journal of the Association of Physicians of India*, 2017 Feb 1; 65(1): 1-2.
- Theobald HE. Dietary calcium and health. *Nutrition Bulletin*, 2005 Sep; 30(3): 237-77.
- Murphy E, Williams GR. Hypocalcaemia. *Medicine*, 2009 Sep 1; 37(9): 465-8.

32. Pepe J, Colangelo L, Biamonte F, Sonato C, Danese VC, Cecchetti V, Occhiuto M, Piazzolla V, De Martino V, Ferrone F, Minisola S. Diagnosis and management of hypocalcemia. *Endocrine*, 2020 Sep; 69: 485-95.
33. Fong J, Khan A. Hypocalcemia: updates in diagnosis and management for primary care. *Canadian family physician*, 2012 Feb 1; 58(2): 158-62.
34. Goltzman D, Mannstadt M, Marcocci C. Physiology of the calcium-parathyroid hormone-vitamin D axis. *Vitamin D in clinical medicine*, 2018; 50: 1-3.
35. Burns CM. The calcium content of muscle. *Biochemical Journal*, 1933; 27(1): 22.
36. Heaney RP. Calcium intake and disease prevention. *Arquivos Brasileiros de Endocrinologia & Metabologia*, 2006; 50: 685-93.
37. Pfeifer M, Begerow B, Minne HW. Vitamin D and muscle function. *Osteoporosis international*, 2002 Mar; 13: 187-94.
38. Chanchlani R, Nemer P, Sinha R, Nemer L, Krishnappa V, Sochett E, Safadi F, Raina R. An overview of rickets in children. *Kidney international reports*, 2020 Jul 1; 5(7): 980-90.
39. Prentice A. Nutritional rickets around the world. *The Journal of steroid biochemistry and molecular biology*, 2013 Jul 1; 136: 201-6.
40. Bouillon R, Antonio L. Nutritional rickets: Historic overview and plan for worldwide eradication. *The Journal of steroid biochemistry and molecular biology*, 2020 Apr 1; 198: 105563.
41. Strand MA, Perry J, Jin M, Tracer DP, Fischer PR, Zhang P, Xi W, Li S. Diagnosis of rickets and reassessment of prevalence among rural children in northern China. *Pediatrics International*, 2007 Apr; 49(2): 202-9.
42. Cesur Y, Caksen H, Gündem A, Kirimi E, Odabaş D. Comparison of low and high dose of vitamin D treatment in nutritional vitamin D deficiency rickets. *Journal of pediatric endocrinology and metabolism*, 2003 Oct; 16(8): 1105-10.
43. Abdnezhad R, Simbar M, Sheikhan Z, Mojab F, Nasiri M. The effect of Salvia (Sage) extract on the emotional symptoms of premenstrual syndrome. *Iran J Obstet Gynecol Infertil.*, 2017; 20: 84-94.
44. Lo CK, Mertz D, Loeb M. Newcastle-Ottawa Scale: comparing reviewers' to authors' assessments. *BMC Med Res Methodol.*, 2014; 14: 45.
45. Halbreich U, O'Brien PM, Eriksson E, Bäckström T, Yonkers KA, Freeman EW. Are there differential symptom profiles that improve in response to different pharmacological treatments of premenstrual syndrome/premenstrual dysphoric disorder? *CNS Drugs*, 2006; 20: 523-547.
46. Derman O, Kanbur NÖ, Tokur TE, Kutluk T. Premenstrual syndrome and associated symptoms in adolescent girls. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 2004 Oct 15; 116(2): 201-6.
47. Hudson T. Using nutrition to relieve primary dysmenorrhea. *Alternative & Complementary Therapies*, 2007 Jun 1; 13(3): 125-8.
48. Bendich A. The potential for dietary supplements to reduce premenstrual syndrome (PMS) symptoms. *Journal of the American College of Nutrition*, 2000 Feb 1; 19(1): 3-12.
49. Freeman EW. Premenstrual syndrome and premenstrual dysphoric disorder: definitions and diagnosis. *Psychoneuroendocrinology*, 2003 Aug 1; 28: 25-37.
50. Ismail KM, O'Brien S. Premenstrual syndrome. *Current Obstetrics & Gynaecology*, 2005 Feb 1; 15(1): 25-30.
51. Leung EK. Parathyroid hormone. In *Advances in Clinical Chemistry*, 2021 Jan 1; 101: 41-93 Elsevier.
52. Carmeliet G, Dermauw V, Bouillon R. Vitamin D signaling in calcium and bone homeostasis: a delicate balance. *Best Practice & Research Clinical Endocrinology & Metabolism*, 2015 Aug 1; 29(4): 621-31.
53. Rosol TJ, Capen CC. Calcium-regulating hormones and diseases of abnormal mineral (calcium, phosphorus, magnesium) metabolism. In *Clinical biochemistry of domestic animals*, 1997 Jan 1; 619-702 Academic press.
54. Roop JK. Hormone imbalance—A cause for concern in women. *Research Journal of Life Sciences, Bioinformatics, Pharmaceuticals and Chemical*, 2018; 4: 237-51.
55. Bollerslev J, Rejnmark L, Marcocci C, Shoback DM, Sitges-Serra A, Van Biesen W, Dekkers OM. European Society of Endocrinology Clinical Guideline: Treatment of chronic hypoparathyroidism in adults. *European journal of endocrinology*, 2015 Aug; 173(2): G1-20.
56. Brecht P, Dring JC, Yanez F, Styczeń A, Mertowska P, Mertowski S, Grywalska E. How do minerals, vitamins, and intestinal microbiota affect the development and progression of heart disease in adult and pediatric patients?. *Nutrients*, 2023 Jul 24; 15(14): 3264.
57. Morciano G, Rimessi A, Patergnani S, Vitto VA, Danese A, Kahsay A, Palumbo L, Bonora M, Wieckowski MR, Giorgi C, Pinton P. Calcium dysregulation in heart diseases: Targeting calcium channels to achieve a correct calcium homeostasis. *Pharmacological Research*, 2022 Mar 1; 177: 106119.
58. Villa-Etchegoyen C, Lombarte M, Matamoros N, Belizán JM, Cormick G. Mechanisms involved in the relationship between low calcium intake and high blood pressure. *Nutrients*, 2019 May 18; 11(5): 1112.
59. Mihai R, Farndon JR. Parathyroid disease and calcium metabolism. *British journal of anaesthesia*, 2000 Jul 1; 85(1): 29-43.
60. Azeez TA. Osteoporosis and cardiovascular disease: a review. *Molecular Biology Reports*, 2023 Feb; 50(2): 1753-63.

61. Davies SW. Clinical presentation and diagnosis of coronary artery disease: stable angina. *British medical bulletin*, 2001 Oct 1; 59(1): 17-27.
62. Surawicz B. Role of electrolytes in etiology and management of cardiac arrhythmias. *Progress in cardiovascular diseases*, 1966 Jan 1; 8(4): 364-86.
63. Hammad M, Maher A, Wang K, Jiang F, Amrani M. Detection of abnormal heart conditions based on characteristics of ECG signals. *Measurement*, 2018 Sep 1; 125: 634-44.
64. Marwick TH. The role of echocardiography in heart failure. *Journal of Nuclear Medicine*, 2015 Jun 1; 56(Supplement 4): 31S-8S.
65. Elmer PJ, Obarzanek E, Vollmer WM, Simons-Morton D, Stevens VJ, Young DR, Lin PH, Champagne C, Harsha DW, Svetkey LP, Ard J. Effects of comprehensive lifestyle modification on diet, weight, physical fitness, and blood pressure control: 18-month results of a randomized trial. *Annals of internal medicine*, 2006 Apr 4; 144(7): 485-95.
66. Srivastava S, Flora SJ. Fluoride in drinking water and skeletal fluorosis: a review of the global impact. *Current environmental health reports*, 2020 Jun; 7: 140-6.
67. Albers HF. Tooth-colored restoratives: principles and techniques. PMPH-USA; 2002.
68. Stefanac SJ, Nesbit SP. Diagnosis and Treatment Planning in Dentistry: Diagnosis and Treatment Planning in Dentistry-E-Book. Elsevier Health Sciences; 2023 Jan 27.
69. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. *Public health nutrition*, 2004 Feb; 7(1a): 201-26.
70. Lin JT, Lane JM. Osteoporosis: a review. *Clinical Orthopaedics and Related Research*®, 2004 Aug 1; 425: 126-34.
71. Smith RO. Osteoporosis: cause and management. *British Medical Journal (Clinical research ed.)*, 1987 Feb 2; 294(6568): 329.
72. Lee SJ, Kanis JA. An association between osteoporosis and premenstrual symptoms and postmenopausal symptoms. *Bone and mineral*, 1994 Feb 1; 24(2): 127-34.
73. Gourlay ML, Fine JP, Preisser JS, May RC, Li C, Lui LY, Ransohoff DF, Cauley JA, Ensrud KE. Bone-density testing interval and transition to osteoporosis in older women. *New England Journal of Medicine*, 2012 Jan 19; 366(3): 225-33.
74. Sweet MG, Sweet JM, Jeremiah MP, Galazka SS. Diagnosis and treatment of osteoporosis. *American family physician*, 2009 Feb 1; 79(3): 193-200.
75. Yang Y, Wang B, Fei Q, Meng Q, Li D, Tang H, Li J, Su N. Validation of an osteoporosis self-assessment tool to identify primary osteoporosis and new osteoporotic vertebral fractures in postmenopausal Chinese women in Beijing. *BMC musculoskeletal disorders*, 2013 Dec; 14: 1-8.
76. Rose D, Preethi T, Prakasam KA. A Review on Osteoporosis. *Int. J. All Res. Educ. Sci. Methods (IJARESM)*, 2022; 10: 2171-8.
77. Rizzoli R, Biver E, Brennan-Speranza TC. Nutritional intake and bone health. *The lancet Diabetes & endocrinology*, 2021 Sep 1; 9(9): 606-21.
78. Manual A. Dietary guidelines for Indians. *Nat Inst Nutrition*, 2011; 2: 89-117.