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Insufficient levels of vitamin D and calcium can lead to rickets Narrative Review

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ABSTRACT: Osteoporosis and conjugated bone disorders consider as a public health issue connected with deficiencies in nutrients like vitamin D3 and calcium. This case-control research looking to examine the relationship among serum vitamin D3 and calcium and their impact on bone health. The study results show a direct connection between decreasing vitamin D3 and problems with bones. The statistics even show that owning low amounts of vitamin D3 is more likely to cause bone disorders than having low levels of calcium. This review tempted the correlation among serum levels of vitamin D3 and calcium and bone health. The results show that a deficincy of vitamin D3 is strongly connected to a number of bone disorders, such as osteoporosis. Calcium is very important for healthy bones, but the levels of calcium in the blood don't look to be a good method to said if there are problems with bones. These findings shows the prominence of focusing on vitamin D3 concentrations in exhibition populations. More studies and researches are needed to learn about how calcium impacts the growth of bone illnesses.

Keywords: Vitamin D3, calcium, insufficiency, rickets

1. INTRODUCTION

When you expose to sun light directly on your skin, it produce vitamin D, which is called the "sun shine vitamin." Vitamin D is substantial for monitoring calcium concentrations in the blood, that is significant for the health of the bones and muscles [1]. Not having sufficient of it can cause disorders with the bones, like osteomalacia in adults and rickets in adultness. Even though support milk with vitamin D3 in the 1930s reduced the number of cases of rickets around the world, there are lots of people who have sub clinical vitamin D3 deficiencies. This insufficiency impacts almost 1 billion individuals worldwide, encompassing populations in both industrialized and developing nations [2].

Also, calcium is an important vitamin for human health. Scientific studies initially underscored its importance, particularly throughout the early stages of life, including infancy and childhood, characterized by fast physical development. However, in the last ten years, people's views have changed to recognize how important calcium is for all stages of life, from infancy to old age. Because more people are aware of how important calcium is at every stage of life, there are now more calcium-fortified foods and nutritional supplements on the market that are suitable for a larger variety of ages [3].

When vitamin D enters the body, it changes into its active form, 1,25 dihydroxyvitamin D. This active form binds to and activates the vitamin D receptor (VDR), which is a nuclear transcription factor that is important for controlling gene expression. Vitamin D3 is very important for keeping calcium levels in balance because it helps the intestines absorb more calcium. This is especially important when blood calcium levels are low (hypocalcemia). Vitamin D

primarily acts in the duodenum, although it also influences other sections of the intestine [4]. The reason of the current study is to check the correlation among serum levels of vitamin D3 and calcium, and their impacts on bone health. It works to search the correlation between shortage in the vital nutrients and bone disorders. The study aims to ascertain relationships among diverse groups about serum vitamin D and calcium levels and the incidence of bone-related disorders. The projected results should provide useful information about how these nutrients help keep bones healthy, which could change how doctors counsel diets and treat bone problems in the future [5].

2. VITAMIN D3

Vitamin D is an important fats-soluble nutrition vitamin for animals, play a key role inside the metabolism of calcium (Ca) and phosphorus (P) and in preserving strong, healthful bones. It has a role in multiple biological processes, The uptake of phosphorus and calcium, which regulates the formation and releases of minerals into bones as well as bone abnormalities is managed by parathyroid hormone [6]. The primary sources of vitamin D include supplementation, sunshine (ultraviolet radiation), dietary intake, and. Exposure to sun light synthesises around 90% of the body's vitamin D needs [7], see figure (1).

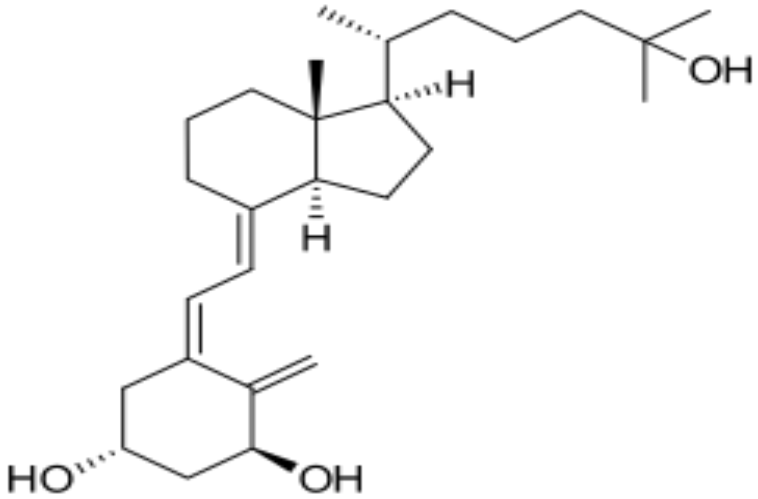

FIGURE 1. - Chemical structure of vitamin D

2.1 MEASUREMENT AND LEVELS

Serum 25-hydroxyvitamin D3 level determines the status of Vitamin D3. Categories of vitamin D status including deficient (20 ng/ml), insufficient (30-50 ng/ml) and sufficient (30-80 ng/ml) are still controversial [8].

2.2 VITAMIN D AND MINERAL HOMEOSTASIS

When dietary calcium is inadequate, 1,25-dihydroxyvitamin D [1,25$(OH)_2$D] enhances calcium delivery through intestinal cells. This process involves increasing the expression of the TRPV6 (brief receptor capability vanilloid 6) calcium channel on the apical membrane and the calcium-binding protein calbindin-D9k. Calcium is then moved out of the cellular throughout the basolateral membrane via PMCA1b (plasma membrane calcium ATPase 1b) [9].

When dietary calcium intake is high, calcium is mainly absorbed through the paracellular pathway. Interestingly, 1,25$(OH)_2$D additionally impacts this manner by means of regulating proteins related to the paracellular course, along with claudin-2 and claudin-12 (additives of tight junctions), cadherin-17 (a cell adhesion protein), and aquaporin eight (a channel within tight junctions). This highlights the large position of vitamin D3 in handling calcium absorption beneath various nutritional conditions [10].

2.3 VITAMIN D3 DEFICIENCY

Vitamin D3 has emerged as a prominent subject of study in scientific research, therapeutic practice, and everyday conversations. In recent years, a thorough study has demonstrated that there is a prevalent deficit of vitamin D3 that has an impact beyond the human skeletal system [11]. Around 30%–50% of the population suffers from vitamin D3 insufficiency, widely recognized as a global health concern [12]. Vitamin D3 is essential for preventing and treating nutritional rickets in toddlers and youngsters, retaining bone health, and supporting severa biological functions. It is broadly recognized that treatment is needed for individuals with severe vitamin D3 deficiency, described by way of serum 25-hydroxy nutrition D levels below 30 nmol/L [13]. There is a nicely-hooked up affiliation between low blood stages of 25-hydroxyvitamin D3 and an multiplied chance of immune-related diseases along with psoriasis, kind 1 diabetes, a couple of sclerosis, rheumatoid arthritis, tuberculosis, sepsis, and breathing infections [14]. A robust

hyperlink additionally exists between diet D3 deficiency and weakened bones, which significantly raises the chance of fractures [15] , see figure (2,3,4).

FIGURE 2. - Vitamin D3 deficiency rickets [13]

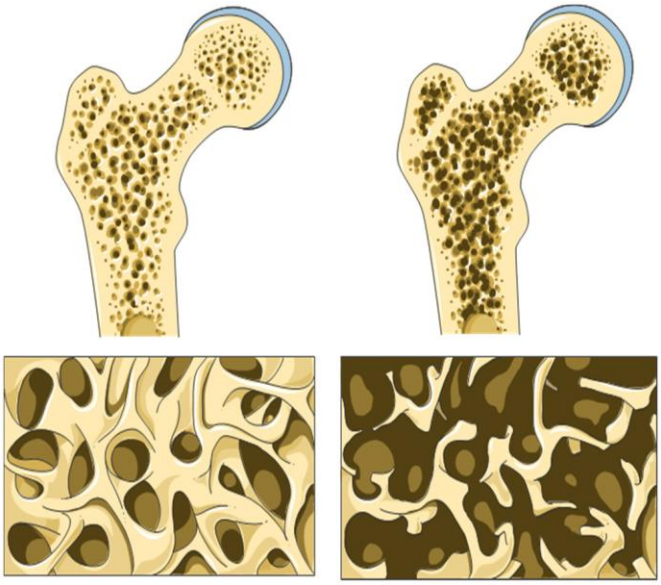

FIGURE 3. - Left – Diagram of a wholesome bone showing a dense and robust bone structure; Right – Diagram of an osteoporotic bone illustrating reduced bone mass and pathological adjustments inside the bone's microarchitecture [14]

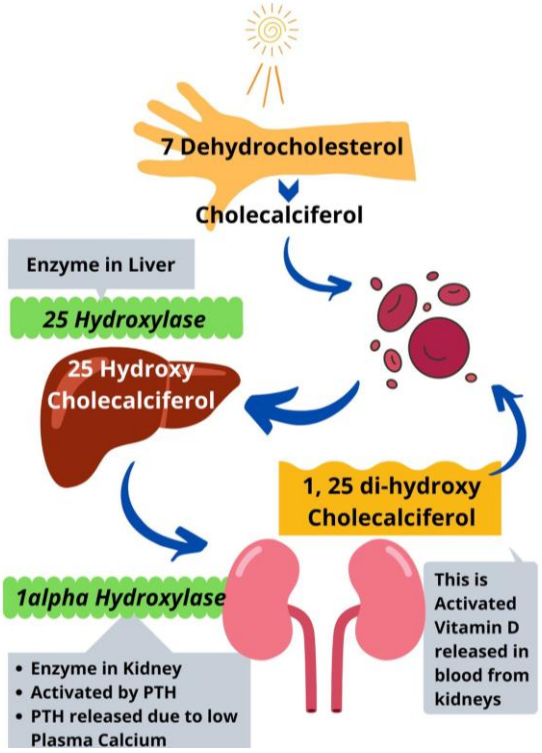

FIGURE 4. - Metabolism of vitamin D

2.4 VITAMIN D3 DEFICIENCY PREVENTION TECHNIQUES

To prevent vitamin D3 deficiency, individuals under the age of 65 who do not receive sufficient sunlight exposure should consume a daily dosage of 600 to 800 IU of vitamin D3. Individuals who are 65 years of age or older should consume a daily dosage of 800 to 1000 IU in order to effectively decrease the likelihood of experiencing fractures and falls [16].

1-Sufficient Sunlight Exposure: Depending on skin type and location, promote safe sunlight exposure for ten to thirty minutes several times a week. This aids in the body's natural production of vitamin D3.

2-Dietary Intake: Consume foods high in vitamin D3, such as egg yolks, mushrooms, fortified dairy products, and fatty fish (salmon, mackerel)

3-Supplementation: Vitamin D3 supplements are advised when diet and sunlight are inadequate, particularly for young children, nursing mothers, the elderly, and those who are more vulnerable.

4. Regular Screening: Blood tests or routine examinations can detect low vitamin D3 levels in people who are at risk.

2.5 VITAMIN D3 SUPPLEMENTATION

The appropriate vitamin D3 dosage for treating deficiency relies upon at the severity of the situation and any associated dangers. Adults can take 6,000 IU daily or 50,000 IU weekly of vitamin D3 for eight weeks. After serum stages rise above 30 ng/mL, a upkeep dose of 1,000 to two,000 IU every day is recommended. Those at high threat may want an preliminary dose of 10,000 IU every day, accompanied by means of a upkeep dose of 3,000 to 6,000 IU once target tiers are executed. Children who have a vitamin D3 deficiency should consume a daily dose of 2,000 IU or a weekly dose of 50,000 IU for a period of six weeks. Once you achieve the desired levels, we recommend taking a daily maintenance dose of 1,000 IU. Breastfed infants and children who consume less than 1 L of vitamin D3-enriched milk should consume 400 IU. Over the past decade, the usage of nutrition D3 dietary supplements has substantially improved for preventing and treating diverse health situations. While epidemiological studies propose a hyperlink between vitamin D3 deficiency and a variety of disorders—including most cancers, autoimmune sicknesses, cardiovascular troubles, melancholy, dementia, infections, and musculoskeletal decline—this affiliation stays debated among professionals [17-20].

3. CALCIUM

Calcium is the most considerable nutrient inside the human frame, with over 99% stored in bones and teeth, totaling more or less 1.2 to at least one. 4 kilograms. In assessment, much less than 1% of the body’s total calcium is

determined in the extracellular serum. People typically absorb approximately 30% of the calcium they consume through diet or supplements. Nevertheless, the pace at which absorption occurs might vary considerably based on a range of circumstances. During pregnancy, the body increases its calcium absorption rate to meet the developing fetus' increased calcium requirements [21]. Calcium levels in the bloodstream are commonly assessed using a vein sample. The ordinary variety for overall calcium is 8.8 to 10. 4 mg/dL, at the same time as ionized calcium typically levels from 4.7 to 5.2 mg/dL. Because albumin is a crucial protein for calcium, it's important to change the overall calcium levels dependent on the levels of albumin. Serum calcium levels stay the same and don't change much when you change the amount of calcium you eat. A small drop in the normal amounts of calcium in the blood causes the body to quickly react in order to restore balance. To avoid hypocalcemia, or a lack of calcium, the body quickly takes calcium from different stores in just a few minutes, using one of three organ systems. So, blood calcium levels may not be a good way to tell how much calcium is in the body as a whole [22-25].

Calcium is necessary in little amounts, yet it is very important for many bodily activities. It plays a role in hormone production, intracellular communication, nerve signal transmission, muscular activity, vasoconstriction, and vasodilation. It is important to look closely at each of these calcium-dependent actions because they are very important for the body. Changes in the amounts of calcium in the blood can affect one or more of these processes. Low blood calcium levels, or hypocalcemia, increase the risk of seizures. This is because calcium is important for sending signals between cells and nerves [26-30].

The human body absorbs calcium through the gastrointestinal system, however the rates of absorption vary by region. About 65% of calcium absorption occurs in regions with a pH ranging from 6.5 to 7.5. As food passes slowly through the ileum, it passively takes in calcium. It is important to remember that the stomach does not help the body absorb calcium [31].

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3.1 CALCIUM DEFICIENCY

Women, especially during certain times in their lives or in certain conditions, people who are allergic to milk or can't digest lactose, and those who are more likely to have nutritional deficiencies, such as teenagers and older people, are the three main groups at higher risk of not getting enough calcium in their diets. This is a really important time for girls' bones to grow and develop, so they are especially at danger. This susceptibility may persist into maturity, particularly for individuals who failed to attain enough bone density during adolescence. Women with eating problems or those engaged in high levels of physical activity, such as individuals affected by the female athlete triad syndrome, encounter considerable hazards. Furthermore, significant focus is directed towards postmenopausal women to assess their vulnerability to calcium insufficiency, which may be affected by hormonal fluctuations that alter bone mineralization [33].

3.2 CALCIUM SUPPLEMENTATION

Older persons, regardless of gender, should aim to eat a daily calcium intake of 1000 to 1200 mg in order to preserve bone health and reduce the risk of fractures [34]. The average daily calcium consumption in Western countries usually falls between 700 and 900 mg, which is below the recommended level for older people. The average consumption in Asia and Africa is even lower. Therefore, in order to meet the recommended calcium requirement of 1000 to 1200 mg/day for the purpose of maintaining healthy bones and preventing fractures, the majority of older people may have to rely on calcium supplements. Many Western countries widely adhere to these recommendations, with over 30–50% of elderly women taking calcium supplements [35]. Scientific studies have demonstrated that the consumption of calcium supplements at a dosage of 1000 mg per day might result in a range of negative consequences, including cardiovascular incidents, the formation of kidney stones, and acute gastrointestinal problems that necessitate hospitalisation. Therefore, experts often advise elderly individuals to enhance their bone health by increasing their dietary calcium intake, rather than relying on supplements [36].

Rickets was identified as a distinct medical condition in the mid-1600s and remains a prevalent issue globally. Recent studies suggest that the rates of incidence and prevalence of rickets are on the rise, especially in developed nations such as the United States. In the early 2000s, the Kingdom said that 7.5 out of every 100,000 children under the age of five had this condition. This bone ailment is marked by high amounts of calcium (Ca) and phosphate (Pi) in the blood, which makes it hard for chondrocytes to grow and change into other types of cells. Chondrocytes are important for bone growth. This interference stops growth plates from getting the right minerals, which is especially bad for long bones and can cause bones to not expand properly. It can also cause typical skeletal problems like bow legs and knock knees [37]. Rickets is primarily categorized into kinds based solely on biochemical anomalies: calcipenic and

phosphopenic. Research shows that hypophosphatemia is the fundamental purpose underlying all types of rickets. Diagnosis commonly involves a aggregate of the affected person's clinical records, physical exam, biochemical assessments, and radiographic imaging. Although the prevalence of nutritional rickets has extensively decreased compared to a century in the past, the condition has started to reemerge even in a few well-resourced countries [38]. Prevention consists of dietary supplementation or fortification with calcium and vitamin D, at the side of ok sunlight publicity. If prevention is unsuccessful, treatment with calcium and/or nutrition D dietary supplements is recommended [39]. For hereditary forms of rickets as a result of vitamin D metabolism or activation defects, administering diet D metabolites is vital [40].

3.3 SYNERGISTIC ROLE OF VITAMIN D AND CALCIUM

Vitamin D and calcium work synergistically to maintain bone health and overall calcium metabolism in the human body. Vitamin D enhances the intestinal absorption of calcium, which is a critical mineral for the formation and maintenance of bone tissue. Without sufficient vitamin D, calcium absorption is reduced, which can lead to bone demineralization and an increased risk of conditions such as osteopenia, osteoporosis, and rickets. Calcium is the first building block of the bone matrix, while vitamin D assists the body to absorb and utilize it. When the two nutrients are exist in the right concentrations, they give the help to the bone mineral density more than when only one is exist. Evidence shows that combined strategies, include exercise and nutritional supplies with calcium and vitamin D, that develop bone health outcomes, especially in populations susceptible to bone loss, such as postmenopausal women [41].

3.4 REVIEW METHODOLOGY

A detailed literature evaluation was proceed utilizing reliable scientific databases, including Google Scholar, PubMed, Scopus, and Web of Science, to identify research that are relevant. The search strategy included English words such as "Vitamin D3," "Calcium," "Insufficiency," and "Rickets," as well as distinct combinations of the used words utilizing Boolean operators (AND / OR). Only papers published in the time of January 12, 2024, and February 2, 2025, were involved to make sure that the study done at recent, peer-reviewed articles which are directly connected to vitamin D3 and calcium absence, especially their health consequences, such as rickets.

Scientific Evaluation: The paper put a line under the important role of vitamin D and calcium in the avoidance of rickets, while even synthesizing the newest knowledge to support healthcare providers.

4. CONCLUSION

This study clarify an important join between vitamin D3 deficiency and the enhancement of bone diseases similar to osteoporosis. It also implies that while calcium is crucial for healthy bones, there could be less of a direct correlation between calcium concentrations in the blood and bone disorders than there is with vitamin D3 concentrations.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest

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