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Clinical implications of Vitamin D deficiency in older adults: An updated review of the literature

Marcin Kwiatkowski[1], Paulina Bochniak[2], Jakub Kołacz[1], Patrycja Oleś[3], Mateusz Bryła[4], Zofia Bryła[5], Monika Spaczyńska-Kwiatkowska[5], Tomasz Włoch[6], Tomasz Koziński[7], Marta Donderska[8]

[1] Department of Internal Medicine, Murcki Provincial Hospital, Katowice, Poland

[2] Familia-Med non-public Healthcare centre in Bieruń, Poland

[3] Faculty of Medicine and Health Sciences, Collegium Medicum, University of Zielona Góra, Poland

[4] Health Centre in Mikołów, Poland

[5] Faculty of Medical Sciences, Medical University of Silesia, Katowice, Poland

[6] Szpakmed Healthcare Centre, Ruda Śląska, Poland

[7] The University Clinical Centre in Gdańsk, Poland

[8] Department of Emergency Medicine, University Clinical Centre, Gdańsk, Poland

Abstract

Vitamin D deficiency is a common health problem worldwide, especially among the elderly. The age-related decline in cutaneous synthesis and absorption from the diet exacerbates this deficiency, which is particularly observed during the winter months at higher latitudes, including Poland. This review paper examines the various roles that vitamin D plays in both skeletal and non-skeletal health. Its deficiency weakens muscle function, causes osteomalacia and raises the risk of fractures. Each of these factors raises the chance of falls, which are common among the elderly. In addition to its impact on the musculoskeletal system, vitamin D also affects the immune system which lessens the severity of illnesses like Coronavirus disease 2019 (COVID-19) and vulnerability to infection. Research is underway on its potential link to neuropsychiatric diseases such as depression and metabolic disorders such as type 1(T1DM) and type 2 diabetes mellitus (T2DM). Public, regularly updated health programs focused on fortification and supplementation, are critical to maintain the right vitamin D levels, especially in the older population. **Methodology**. *This article has been conducted through a literature search, primarily using PubMed, to examine the clinical impact of vitamin D deficiency in the elderly. The search is focused on studies published between 2005 and 2025, with an emphasis on more recent data. The following* **ke -ywords** *and their combinations were used: vitamin D deficiency, aged, bone diseases and geriatrics. (Gerontol Pol 2025; 33; 24-30) doi: 10.53139/GP.20253306*

Keywords: *vitamin D deficiency, aged, bone diseases, geriatrics*

The effects of vitamin D deficiency and vitamin D supplementation in elderly people

The aim of the review was to explore the clinical impact of vitamin D deficiency in older adults, focusing on skeletal, immunological, mental and metabolic health. It highlights how maintaining the right level of vitamin D is essential in maintaining health.

Changes related with age in vitamin D metabolism, including reduced dermal synthesis and absorption, contribute to the high occurrence of vitamin D deficiency in the elderly population [1,2]. Vitamin D supplementation has shown conflicting effects in fracture prevention and bone mineral density, but may be beneficial when combined with calcium, especially in those with frailty syndrome [2]. In addition to skeletal health, vitamin D

Adres do korespondencji / Correspondence address: Department of Internal Medicine, Murcki Provincial Hospital, Sokolowskiego 2, 40-749 Katowice ☎ (+48 32) 255 61 62 marcink998@gmail.com
ORCID: Marcin Kwiatkowski 0009-0004-7238-0708, Paulina Bochniak 0009-0001-3787-6319, Jakub Kołacz 0009-0004-2377-5586, Patrycja Oleś 0009-0001-4825-9789, Mateusz Bryła 0009-0000-4136-2575, Zofia Bryła 0009-0006-9836-5658, Monika Spaczyńska-Kwiatkowska 0000-0003-2660-8674, Tomasz Włoch 0009-0001-7370-3212, Tomasz Koziński 0009-0009-3259-7861, Marta Donderska 0000-0002-7144-4624

deficiency has been linked to a number of other conditions, including autoimmune diseases, neurodegenerative diseases, psychiatric disorders, cardiovascular disease and diabetes. According to the current recommendations, supplementation of vitamin D should be individualized depending on various factors, such as age. Seniors between the age of 65 and 75 should supplement 800-2000 IU/day of vitamin D, depending on body weight and age, while obese patients in this age group should be supplemented with up to 1600-4000 IU daily. Elderly seniors over 75 years of age are advised to supplement 2000-4000 IU of vitamin D per day, with obese elderly seniors being recommended to supplement 4000-8000 IU/day depending on severity of obesity [3].

Physiology and sources of Vitamin D

Vitamin D synthesis commences in the skin when ultraviolet B (UVB) radiation converts 7-dehydrocholesterol into cholecalciferol (vitamin D3), which is then transformed in the liver into 25-hydroxyvitamin D [25(OH)D] and further hydroxylated in the kidneys to its active form, 1,25-dihydroxyvitamin D [1,25(OH)2D] [4,5]. This active form binds to vitamin D receptors (VDRs) to regulate calcium homeostasis, including intestinal absorption, bone metabolism, and kidney reabsorption [6]. Due to reduced sun exposure, dietary sources like UV-exposed plants, mushrooms and yeast provide vitamin D2, while fish, egg yolks, dairy and offal are rich in vitamin D3 [7,8,9]. Vitamin D deficiency can be addressed by fortification, which has demonstrated promise in raising its level. [7,10].

Epidemiology

Vitamin D deficiency is a major global health issue, which is particularly prevalent in the elderly population. According to a meta-analysis of research conducted between 2000 and 2022, 25(OH)D levels below 20 ng/ml (50 nmol/l) are present in around 47.9% of individuals aged 1 year or older, with a higher prevalence in the elderly [11]. Vitamin D deficiency is defined as 20 ng/ml, insufficiency as 21-29 ng/ml and sufficiency as 30 ng/ml and over [12]. Higher latitudes are associated with higher rates of deficiency, which suggests that geographical location has a significant impact on vitamin D status [13]. In Poland vitamin D deficiency is also frequently seen in adults, particularly during the winter and early spring months. Numerous studies carried out in northern Poland (54°N) have consistently discovered low population levels of 25(OH)D. Among 5775 adults in a large study, 65.8% had 25(OH)D levels below 20 ng/ml which is indicative of a deficiency [14]. Other research revealed similar findings with deficiency rates varying from 81.1% in the winter to 42.2% in the fall [15]. According to studies, 82–90% of Polish seniors have vitamin D insufficiency or deficiency with levels below 30 ng/ml [16]. A wintertime vitamin D deficiency (20 ng/ml) affected 83.2% of older women in Warsaw [17]. In a similar vein, in late winter 84.4% of adults in northern Poland lacked adequate amounts of vitamin D [18]. Reduced mobility functional disability and inadequate sun exposure are factors linked to lower vitamin D levels [15,18]. Additionally, older age, male gender, obesity and pregnancy are linked to lower 25(OH)D levels [14,19]. The aforementioned results underscore the necessity of extensive vitamin D supplementation and monitoring initiatives in Poland to tackle this public health issue [18].

Clinical consequences of Vitamin D deficiency

Skeletal and muscle health

Numerous health issues, particularly in the elderly, are linked to vitamin D deficiency. Vitamin D deficiency's effects on skeletal health are its most well-established side effect. For calcium homeostasis and bone health parathyroid hormone (PTH) and vitamin D are essential. Vitamin D deficiency leads to increased PTH production, which improves calcium reabsorption and the conversion of 25-hydroxyvitamin D to 1,25-dihydroxyvitamin D. PTH's function is maintaining calcium homeostasis, which is done mostly by absorbing calcium in the intestines and reducing kidney calcium losses. If these processes do not result in obtaining high enough calcium level, PTH mobilizes osteoclasts to release calcium from the bone matrix [20]. A serum 25-hydroxyvitamin D level below 34 nmol/L is associated with elevated PTH and abnormal bone metabolites in children [21]. PTH and vitamin D work together to create a tightly regulated feedback loop, in which PTH promotes the synthesis of vitamin D and vitamin D inhibits PTH secretion [22]. Vitamin D deficiency and primary hyperparathyroidism (PHPT) are prevalent conditions especially in postmenopausal women [23]. One condition, that is closely linked to a vitamin D deficiency is osteomalacia. It is typified by decreased bone mineralization and manifests in three phases with fluctuating calcium phosphate PTH and alkaline phosphatase levels as vitamin D deficiency worsens [24]. Common symptoms include generalized bone pain, muscle weakness, and skeletal deformities. The condition can lead to increased fracture risk

[25,26]. Diagnosis can be challenging due to non-specific symptoms, which may be mistaken for other conditions, like restless leg syndrome [27]. Vitamin D deficiency is also prevalent among fracture patients, with studies reporting 40-71% of patients having levels below 50 nmol/L. This deficiency is common in both high- and low-energy fractures, particularly among women [28,29]. Vitamin D deficiency causes muscle weakness and increased fall risk [30]. This deficiency can lead to profound muscle weakness and morphological changes in adults. Since the symptoms are non-specific it's important to be aware of the connection between vitamin D level and such symptoms. Vitamin D plays a crucial role in muscle function, affecting cell differentiation, calcium handling, and genomic activity [31].

Immune system

A person's level of vitamin D has a significant impact on its immune-modulatory effects. The regulation of both innate and adaptive immune responses is significantly influenced by vitamin D. It enhances the production of antimicrobial peptides, especially cathelicidin, which helps immune cells and barrier sites eliminate bacteria. Various immune cells express the vitamin D receptor and metabolizing enzymes, which enables localized synthesis of active vitamin D derivative. This autocrine/paracrine action affects antigen-presenting cell function and T cell activation [32,33]. Infections, autoimmune diseases and allergies have all been associated with vitamin D deficiency in both adults and children [34]. Acute respiratory infections, COVID-19, multiple sclerosis, type 1 diabetes and inflammatory bowel disease have all been linked to vitamin D deficiency according to observational studies [35]. There is a noteworthy correlation between the severity and mortality of COVID-19 and vitamin D deficiency. According to meta-analyses and systematic reviews vitamin D deficiency increases the risk of severe COVID-19 consequences such as death and the need for mechanical ventilation [36,37]. The cytokine storm seen in severe COVID-19 cases may be exacerbated, and innate immunity is compromised by vitamin D deficiency. The groups at the highest risk of severe COVID-19 overlap with those at risk of vitamin D deficiency, including the elderly and certain ethnic groups [38].

Diabetes mellitus

It has been found that vitamin D may help prevent T1DM. According to epidemiological research vitamin D deficiency raises the incidence of T1DM but early supplementation may lower risk [39]. While there is conflicting evidence regarding vitamin D intake during pregnancy, a meta-analysis indicated that early life vitamin D intake is linked to a lower risk of T1DM [40]. Through immune system regulation and direct effects on pancreatic beta cells vitamin D has protective effects that may increase the cells resistance to cellular stress [39,41]. Pancreatic and immune cells contain the VDR and specific VDR allelic variants have been associated with T1DM in various countries. On top of that, variations in vitamin D levels may also contribute to seasonal and latitudinal variability in T1DM incidence [42]. Vitamin D deficiency has been also recognized as a potential risk factor for T2DM. It can impact insulin resistance systemic inflammation and pancreatic β-cell function all of which can lead to the development of T2DM [43,44]. In epidemiological research low serum vitamin D levels have been linked to an increased risk of metabolic syndrome and T2DM. However, the exact link between vitamin D deficiency and T2DM is still unknown and the findings of randomized clinical trials are contradictory. Meta-analyses typically reveal no significant impact on glycemic control despite some research suggesting that vitamin D supplementation improves insulin resistance or fasting plasma glucose. The possible advantages of vitamin D supplementation in the prevention and treatment of T2DM are being investigated in large-scale studies [45].

Mental health

Depression is another significant health issue associated with vitamin D deficiency. Given that vitamin D is essential for many brain functions, it was thought that depression could result from a lack of it. Enhancing serotonin synthesis and regulating proinflammatory cytokines are two possible ways in which vitamin could help treat depression [46]. Hence, the meta-analysis has been conducted which found that individuals with lower vitamin D levels had higher odds of developing depression. Depression is associated with significant disability, mortality, and health care costs [47]. Moreover, a longitudinal study on community-dwelling older adults demonstrated that vitamin D deficiency was associated with a higher likelihood of incident depression, even after controlling for relevant covariates. Suicide is caused by a combination of different factors, of which depression is one of the most frequent. It is worth noting that vitamin D supplementation shows promise in reducing suicide risk, a major concern in depression. More than 700 thousand people die of suicide annually [46]. These findings are of great importance, since vitamin D deficiency is highly prevalent among the elderly [48].

Other than that, a cross-sectional study found that vitamin D deficiency was correlated with low mood and impaired cognitive performance in older adults, including those with mild Alzheimer's disease (AD) [49]. Vitamin D supplementation has also been connected with lower chance of developing Parkinson's disease (PD). It is thus suggested that higher vitamin D level is a protective factor and a low level is a risk factor for PD. [50] Vitamin D is essential for preserving healthy brain function safeguarding neurons and adjusting synaptic structure [51]. It is becoming more and more crucial to comprehend how vitamin D affects mental health as the population ages [52].

Chronic rhinitis

Studies have looked into the relationship between vitamin D deficiency and chronic rhinitis (CR). The researchers examined a large group of patients who were 40 years of age and older and found a 21.1% presence of CR. The prevalence of vitamin D deficiency was higher and mean vitamin D levels were lower in people with CR compared with people without the condition. After adjusting for confounding variables there was still a correlation between vitamin D deficiency and an increased risk of CR. Vitamin D's role in immune system, inhibiting production of pro-inflammatory cytokines and promoting repairment and proliferation of respiratory epithelial cells may play a part in alleviating symptoms of chronic rhinitis [53]. Patients with CR with vitamin D deficiency experienced significant improvement in nasal symptoms after oral vitamin D supplementation, hence showing, that maintaining adequate vitamin D levels may be important in managing the disease in middle-aged and older adults, highlighting a potential avenue for intervention and treatment [53,54].

Conclusions

Vitamin D deficiency is a pressing issue, especially in the elderly, who face unique vulnerabilities due to physiological changes associated with aging. This review addresses skeletal, immunological, metabolic and mental health domains to highlight the complex effects of vitamin D's deficiency. Although osteomalacia and fracture susceptibility are well-known skeletal effects, the deficiency's wider ramifications such as its connections to immunological disorders, diabetes and depression demand immediate and ongoing attention. The prevalence of vitamin D deficiency is high especially among older people and in higher latitudes, which emphasizes how inadequate natural sources of diet and sun exposure are to meet physiological needs. While existing strategies, such as food fortification and supplementation programmes, offer promising avenues for reducing this disparity, they must be enhanced and updated to achieve optimal efficacy. It is of the utmost importance that supplementation and other strategies are employed to meet the specific requirements of the elderly, who frequently encounter additional challenges such as restricted mobility and dietary restrictions. Even though, there are recommendations for vitamin D supplementation, further research is needed to evaluate the long-term impact on the general population, to optimise supplementation protocols and to elucidate the dose-response relationship between vitamin D and different health outcomes. It is important to investigate the manner in which vitamin D interacts with other nutrients and to ascertain its role in a variety of health situations. Ultimately, the treatment of vitamin D deficiency requires a comprehensive strategy that incorporates education, public health policy and preventive healthcare. It is incumbent upon health systems to prioritise the alleviation of avoidable disease and enhancement of quality of life, particularly in older populations where deficiencies have the most significant impact.

Conflict of interest
none

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