



Unlocking the Potential: Vitamin D's Impact on Kidney Health

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ABSTRACT:

One of the most vital components of the human body that is crucial to both health and sickness is vitamin D, or vitamin D. It's a member of the fat-soluble secosteroid family, which is obtained by diet or direct solar radiation, which is what produces the precursor of vitamin D from 7-hydroxycholesterol. An alternate process is called bio-activation, which yields an active version of vitamin D (Vit. D₃). This vitamin aids in a number of notable processes, such as detoxification, calcium homeostasis, bone remodeling, and glucose control. It has been discovered that vitamin D plays a critical role in kidney illness and that a lack of it causes renal dysfunction and other disorders related to the kidneys. In addition to the direct link between vitamin D and kidney illness, research has also looked at the interaction between kidney function and adipocytes and adipokines. Numerous studies look into the noteworthy impact of vitamin D in kidney illness. It has been discovered that vitamin D plays a crucial part in metabolism and renal function. So, it is important to discuss that vitamin D has crucial role on kidney in this article.

keywords: Vitamin D; Renal function; Deficiency; CKD; Homeostasis; Metabolism; Ergocalciferol

Introduction:

Before vitamin D was discovered, along with the potential benefits of cod oil and UV radiation, rickets was a common symptom of chronic kidney disease (CKD), which is now understood to be the result of a combined deficit in both calcium and vitamin D. Subsequently, cholecalciferol, or vitamin D₃, supplements have been a staple of treatment ever since, particularly for kids whose skeletons are continuing to expand. A sharp drop in the incidence of rickets was caused by the fortification of dairy products with vitamin D [1]. The active form of cholecalciferol, 1,25-dihydroxycholecalciferol (1,25(OH)₂D₃), is produced by two posttranslational metabolic processes, the most prevalent of which takes place in the kidney under physiological conditions [2]. The idea that vitamin D deficiency could be the cause of much more comorbidity than just mineral and bone disorders was fueled by the nearly universal expression of the vitamin D receptor, the discovery that many tissues other than the kidneys can also generate 1,25(OH)₂D₃, and the demonstration of pleiotropic effects of 1,25(OH)₂D₃ in animal models and experimental systems.

A progressive loss of renal function that frequently results in end-stage renal disease (ESRD), a significant risk of cardiovascular disease, and a high mortality rate are the hallmarks of chronic kidney disease (CKD) [3]. As of right now, the recommended course of treatment for people with chronic kidney disease (CKD) includes strict blood pressure management as well as angiotensin receptor blockers, statins, and angiotensin-converting enzyme inhibitors. Nevertheless, the morbidity and mortality rates for people with CKD remain high even with current therapeutic options [4].

Studies conducted over time have contributed to our understanding of the molecular and clinical implications of the relationship between CKD and impaired vitamin D metabolism. Vitamin D deficiencies, such as those in individuals with chronic kidney disease (CKD) and the general population, are now considered a global epidemic. Examples of these are 25-hydroxyvitamin D [25(OH)D₃] and 1,25-dihydroxyvitamin D [1,25(OH)₂D₃] [5, 6]. Multiple observational studies have shown a significant correlation between reduced glomerular filtration rate (GFR), vitamin D insufficiency, and higher death rates among CKD patients [7-9]. Beyond the usual control of calcium and phosphorus homeostasis and skeletal integrity, the vitamin D endocrine system plays a vital role in disease prevention due to its potentially pleiotropic effects on extra-mineral metabolism, including kidney function.

Prevalence and function:

Vitamin D, sometimes known as vitamin D, is a fat-soluble vitamin that occurs in two biological forms: vitamin D₃, also known as cholecalciferol, which is found in human tissue, and vitamin D₂, also known as ergocalciferol, which is found in some fish and plants. The skin produces active vitamin D through the reaction of sunshine with the precursor. The human body can manufacture it through two methods: consumption or exposure to sufficient direct sunlight. The body uses vitamin D for a variety of essential processes, including immune-modulating and hormone-related tasks [10, 11]. Its correlation with many disease states has been shown, and its insufficiency is linked to general morbidity in a range of illnesses, including cancer, autoimmune diseases, and cardiovascular problems [12, 13].

The initial hydroxylation is performed on the Vit. D precursor, which is transformed into 25-hydroxyvitamin D (25(OH)D), the inactive form of Vit. D, and at the end, it is transported to the kidney, where it undergoes the second hydroxylation, which produces 1,25(OH)D, an active form of Vit. D. The active circulating Vit. D then binds to the DBP in the plasma and impacts its various targets through the Vit. D receptor (VDR) [14]. The half-life of Vit. D in the body is 3 weeks, which should be supplemented either via nutrition or exposure to sunlight. Vit. D exerts its effect by genomic reaction and protein synthesis via its specific receptor (VDR), [15] or non-genomic action through the cell membrane by another receptor, known as 1,25D3-membrane-associated, rapid response steroid-binding receptor (MARRS) (ERp57) [16].

Vitamin D controls the genes in the bone that are in charge of reproduction, glucose regulation, and bone remodeling. It appears that while higher amounts of vitamin D cause restricted resorption and mineralization to sculpt bone, the ideal concentration of vitamin D appears to aid in bone growth. In the bone, vitamin D has both anabolic and catabolic effects. Vitamin D inhibits osteoblastogenesis, the opposite of parathyroid hormone (PTH), which is how it catabolizes. As the osteoblast's activator, vitamin D has a positive impact on osteopontin, which in turn promotes osteoblast migration, growth, and survival—the anabolic action on the bone.

Indication of vitamin D deficiency:

According to several standards, a reading below a specific 25-hydroxyvitamin D (25(OH)D) threshold indicates a vitamin D deficiency. A minimum concentration of 50 nmol/l is defined by the National Academy of Medicine [17], while the Endocrine Society defines deficiency as levels below 30 nmol/l for children and young adults and insufficiency as values between 30 and 50 nmol/l. For older persons, a minimum concentration of 75 nmol/l is advised [11, 18]. For most people with CKD, the prevalence of vitamin D deficiency is similar to those without CKD, although one report from South Korea observed twice the prevalence of vitamin D deficiency for stage 5 CKD compared with stage 3, from 40.7% to 85.7% [19, 20].

Deficiency in vitamin D as a particular in the development of CKD:

Recent epidemiological studies have clearly shown the high frequency of vitamin D insufficiency or inadequacy in CKD patients. Although there is no agreement on the ideal levels of vitamin D, the Kidney Disease Improving Global Outcomes guidelines that were recently released propose that vitamin D deficiency be defined as blood 25(OH)D levels < 10 to 15 ng/mL (25 to 37 nmol/L) and insufficiency as serum 25(OH)D levels > 10 but < 20 to 32 ng/mL (50 to 80 nmol/L) [21]. Nonetheless, most researches characterise serum 25(OH)D concentrations as follows: < 20 ng/mL as inadequate, < 20 to 29.9 ng/mL as inadequate, and ≥ 30 ng/mL as adequate [22]. A decline in serum 1,25(OH)2D was noted in the early stages of chronic kidney disease (CKD) in a large population-based study, prior to a significant increase in PTH or hyperphosphatemia [23]. Furthermore, it seems that as kidney disease advances, the prevalence of deficiency rises [24]. Serum 25(OH)D is an independent inverse predictor of kidney disease progression and death in patients with earlier stages of chronic kidney disease (CKD), according to an interesting retrospective study [25].

Reductions in renal inflammation and proteinuria are thought to be key factors in the development of cardiovascular and renal disorders [26, 27]. Numerous investigations have demonstrated a link between an elevated level of albuminuria and a vitamin D deficit [28]. In addition to the present use of RAAS blocking, active vitamin D therapy with either paricalcitol or calcitriol provided a considerable reduction of proteinuria in individuals with CKD [29]. According to that study, individuals getting active vitamin D experienced a 16% drop in proteinuria, whereas those receiving a control medication experienced a 6% rise.

Cardiovascular disease has been linked to vitamin D deficiency in both the general population and patients with chronic kidney disease (CKD) [30]. In experimental models of cardiac hypertrophy, treatment with active vitamin D reduces myocardial hypertrophy and delays the onset of heart failure [31].

Impact of vitamin D in Kidney:

In the gut, vitamin D₂ and D₃ are absorbed from food. In the meantime, sunshine can help the skin create vitamin D₃, and both products are then transported to the liver, where the first hydroxylation (23-hydroxylation) takes place. This primary metabolite of vitamin D travels to the kidneys and other organs for the last stage of activation, hydroxylation, where it changes into calcitriol, the active form of vitamin D that subsequently uses its particular receptor (VDR) to carry out crucial biological functions [32]. Phosphate reabsorption by VDR on the proximal tubule is directly impacted by 1,25D. The klotho gene and VDR element are induced in renal tubules to produce the aforementioned result. Furthermore, via working with fibroblast-growth factors (FGFs) and a secreted form of klotho, 1,25D benefits the kidneys [33]. The metabolism and absorption of calcium are also significantly impacted by 1,25D. Through its receptor, VDR, 1,25D activity in the kidneys affects almost every cell in the body. Conversely, vitamin D plays a major part in a number of illnesses, including those of the heart, brain, metabolism, kidney, and cancer.

Conclusion:

Vitamin D is very beneficial for blood, bone, and homeostasis, as well as for many organs like the kidneys. Numerous studies have looked into the precise function of vitamin D in the kidney and how it relates to other organs like the adipocyte. Adipokines and vitamin D together can have positive impacts on the advancement of health and the prevention of disease. It is important to have enough vitamin D because of the connection between PTH and minerals (such as calcium and phosphorus) and the function of vitamin D supplements in dialysis patients and those suffering from kidney failure. In

conclusion, there isn't much evidence to support the indiscriminate use of vitamin D pills among CKD patients or the general public. This is still the most scientifically proven use of vitamin D. Giving high-risk populations vitamin D supplements may reduce their risk of fracture.

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