

# Sunlight Deficiency: a Reversible Cause of Low Serum Phosphate?

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## Abstract



Vitamin D deficiency is associated with low circulating levels of calcium and phosphate.

A 56-year-old asymptomatic gentleman was referred with laboratory findings of undetectable serum phosphate (<0.16 mmol/L) and a history of calcified renal calculi. 25-hydroxyvitamin D (25-OHD) was low at 19.0 nmol/L (concentrations of <30 nmol/L are indicative of vitamin D deficiency). Serum adjusted calcium was normal at 2.38 mmol/L (reference range (RR): 2.0–2.6), as was parathyroid hormone. 24-h urine calcium excretion was elevated at 10.8 mmol per 24 h (RR: 2.5–7.5), with normal 24-h urinary phosphate (RR: 12.9–42.0 mmol/24 h). Renal function was normal.

## Introduction



Vitamin D deficiency is very common in the UK, as described in reports over recent years [1,2]. Vitamin D deficiency related problems of rickets in children, and osteomalacia or increased fracture risk in adults, remain a significant public health issue, even though the links have been known since the 1920s [1–3].

Historically, the first attention to rickets, which we now know to be caused by Vitamin D deficiency, was described in England by Daniel Whistler in 1645 [4]. 6 years later Francis Glisson (1651) provided a classic description of the disease. It was described as a disease that occurred in young children, produced severe deformities and was often fatal. The condition, which was known in Europe as “the English disease”, was more common in the cities than in rural areas [4]. Prior to the industrial revolution, it was associated with affluence, as the children of well-to-do families were often completely covered by clothing and were kept indoors away from sunlight.

On questioning, it was revealed that he worked indoors between 06.00 h and 15.00 h for approximately 24 days per month, and on rest days he went out mainly in the evenings.

Achievement of adequate sunlight exposure resulted in normalisation of 25-OHD status and serum phosphate levels. In relation to normalisation of vitamin D status, there was a reduction in urinary calcium excretion, which when elevated may have contributed to the renal calculi.

The authors propose that investigation of low phosphate or calcium levels should always include an assessment of time spent outdoors in the daytime and vitamin D status.

There is now increasing evidence that vitamin D insufficiency may play a role in the aetiology of a number of other chronic diseases such as hypertension, cardiovascular disease and diabetes mellitus (both type 1 and type 2), and possibly some cancers [1,3,5].

More than 90% of a person's vitamin D requirement comes from casual exposure to sunlight, with very few foods naturally containing vitamin D. When solar ultraviolet B radiation (UVB; wavelength 290–315 nm) penetrates the skin, 7-dehydrocholesterol in the plasma membrane of skin cells absorbs it, resulting in the ring opening of 7-dehydrocholesterol to form pre-vitamin D<sub>3</sub> [6]. Pre-vitamin D<sub>3</sub> is thermodynamically unstable and is rapidly converted to vitamin D<sub>3</sub>. At the latitude of London, United Kingdom, little if any vitamin D<sub>3</sub> is made from sunlight exposure between the middle of October and early March. Circulating vitamin D<sub>3</sub> levels in summer are 30–100% higher than winter values [7]. Increased skin pigmentation and habitual application of topical sunscreens can reduce the number of

UVB photons entering the skin by as much as 99%, and glass absorbs all UVB. Moreover, institutionalised or house bound individuals, and those covering up virtually all of their skin with occlusive garments for religious reasons, are also at risk. Only a few natural foods, such as eel, herring and salmon, are good sources of vitamin D. Dietary vitamin D is thought to contribute only 10–20% of human vitamin D supply.

Once vitamin D<sub>3</sub> is made in the skin, or is ingested in the diet as vitamin D<sub>2</sub>, it undergoes 25-hydroxylation in the liver to 25-hydroxyvitamin D<sub>3</sub> (25-OHD<sub>3</sub>) or 25-OHD<sub>2</sub>, respectively. 25-OHD is then further hydroxylated in the kidney to 1,25-di-OHD, the metabolically active form. This form of hydroxylated vitamin D<sub>3</sub> is required for both phosphate and calcium absorption in the small intestine and resorption from bone, together with actions on the parathyroid gland mediated through interaction with its specific nuclear vitamin D receptor (VDR). Recently, it has been recognised that most tissues in the body also possess the 25-OHD-1 $\alpha$ -hydroxylase and thus have the capacity locally to produce 1,25-di-OHD [8]. Vitamin D deficiency is associated with low circulating calcium and phosphate levels. Clinical symptoms and signs of vitamin D deficiency include muscle pain, limb girdle pain, hypocalcaemia, proximal myopathy, pathological fracture, tetany, and seizures.

Herein, the current authors report a case of an asymptomatic man whose serum phosphate deficiency was found to be secondary to vitamin D<sub>3</sub> deficiency as a consequence of low sunlight exposure.

### Case Report

A 56-year-old asymptomatic man of White European origin was referred with laboratory findings of undetectable serum phosphate (<0.16 mmol/L) and a history of calcified renal calculi. 25-OHD<sub>3</sub> was low at 19.0 nmol/L (concentrations of <30 nmol/L are indicative of vitamin D deficiency). The calculi had manifest in the winter months and were passed spontaneously. Our patient was on no medication at the time of presentation with the renal calculi. Serum adjusted calcium was normal at 2.38 mmol/L (reference range (RR): 2.0–2.6) as was parathyroid hormone at 2.2 pmol/L (RR: 1.1–6.9). 24-h urine calcium excretion was elevated at 10.8 mmol/24 h (RR: 2.5–7.5) with normal 24-h urinary phosphate, although at the high end of the range (RR: 12.9–42.0 mmol/24 h). Renal function was normal with both urea and creatinine within their respective reference ranges and the estimated glomerular filtration rate (eGFR) >90 ml/min. Questioning revealed that he worked indoors between 06.00 h and 15.00 h for approximately 24 days per month, and on rest days he went out mainly in the evenings. Dietician analysis revealed a normal dietary intake of calcium and of phosphorus.

### Management

Sunlight exposure during the spring was encouraged. Dietitian review indicated that the low serum phosphate was not due to dietary insufficiency, and he maintained a good intake of dairy products. At the next review in early summer, 25-OHD level had improved to 56.4 nmol/L (concentrations >50 nmol/L are indicative of vitamin D adequacy), and phosphate was near normal at 0.66 mmol/L (RR: 0.8–1.5). By mid-summer, there was complete normalisation of phosphate levels (0.83 mmol/L), with 25-OHD remaining normal. Urinary calcium excretion decreased to 6.9 mmol/24 h (RR: 2.5–7.5 mmol/24 h).

### Discussion

In this case, simply encouraging adequate sunlight exposure resulted in normalisation of vitamin D status and serum phosphate. In relation to normalisation of vitamin D status, there was a reduction of urinary calcium excretion, which when elevated may have contributed to the development of renal calculi. In the presence of severe hypophosphatemia, the 24-h urinary phosphate level was inappropriately normal (but at the high end of the reference range), suggesting renal phosphate wasting might have occurred previously. However, as the hypophosphataemia became severe, very little phosphate was then available for excretion in the urine. The circulating level of fibroblast growth factor (FGF23) was not measured and dysregulation of FGF23 function probably contributed to severe hypophosphatemia in this case.

Most experts agree that a 25-OHD level of >50 nmol/L is the minimum level for vitamin D sufficiency. However, studies have shown that >75 nmol/L of 25-OHD, PTH levels are at their ideal concentration [9–11].

Environmental UVB exposure is the most important source natural source of vitamin D. There is considerable controversy about the extent of sun exposure which should be recommended, given the association of skin cancers with excess UVB exposure. However, the UK National Diet and Nutrition Survey [12] demonstrated high rates of vitamin D deficiency. If untreated, the associated chronic disorders place heavy burdens on the individual and on the state. It has been suggested that the equivalent of 15 min of mid-summer sun exposure at noon on a weekly basis is sufficient to give adequate vitamin D levels in adults throughout the year [13, 14]. In Northern European office or factory workers, this equates to the amount of sunlight exposure achieved during casual outdoor sojourns, principally at weekends.

Our case highlights the importance of investigating low serum phosphate or calcium levels, with the need to always take a sunlight exposure history and check vitamin D status. In all patients presenting with vitamin D deficiency, it is paramount to determine the level of exposure to sunlight. One limitation in this case study was the lack of previous vitamin D levels or bone profile results.

The patient has maintained the changes to his lifestyle and continues to get optimal sunlight exposure. This non-pharmacological intervention has resulted in normalisation of his phosphate and vitamin D levels. The relevance of vitamin D to health needs to be recognised by all of us [1, 2].

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### Ethical Approval

Informed consent obtained.

### Contributors

AHH wrote the first draft of the manuscript. DR and SN were involved in data collection and contributed to the writing of the paper. ML provided scientific advice and helped with the litera-

ture review and final drafting of the manuscript. All authors approved the final version of the manuscript.

### Guarantor



AHH.

**Conflict of interest:** None to declare.

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