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# VITAMIN D AND HUMAN HEALTH: AN OVERVIEW

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**ABSTRACT**

Vitamin D was previously considered essential mainly for the bone health. However its extra skeletal role diverted attention of scientists worldwide. Recent studies explored its importance in almost all vital functions of the human body. Its deficiency has become a pandemic across the globe. This is evident in many studies correlating vitamin D deficiency with a variety of diseases and disorders including bone weakness, cardiovascular dysfunctions, Immune disorders, metabolic disorders, brain health and cancer. In Pakistan, vitamin D deficiency is also prevalent among diseased and healthy individuals. Furthermore, lack of awareness about the consequences of its deficiency persists among the general population and even health professionals. Hence the aim of this mini review is to describe the vital role of vitamin D in different aspects of human health and correlation of its deficiency with different disease conditions.

**KEYWORDS:** Vitamin D, Health problems, Vitamin D deficiency.

## INTRODUCTION

Balanced diet is considered as a key factor for the proper development and growth of the human body (Sarwar *et al*., 2015). Balanced diet means that it contains all the essential nutrients which are essential for our health. These essential nutrients include carbohydrate, protein, lipids, minerals and vitamins, etc. The deficiency of one or more than one essential nutrients can lead to minor or severe damage to our health. Among these, vitamin D is also considered as one of the essential nutrients in our body (Mann &Truswell, 2012). It is synthesized in our body by means of photosynthesis (Holick *et al*., 1980). Ultraviolet rays from the sun play an important role in its synthesis in the body (Kockott *et al*., 2016). In addition, vitamin D could be obtained from food, but in very less quantity.

Previously, vitamin D was thought to be associated with bone health only. But recent research described that bone health is only the tip of the iceberg with which vitamin D deals with our body. Vitamin D deals with almost all tissues and organs in our body, including brain, heart, pancreas, blood and vascular system, colon, bones, immune system etc. (Hoffmann *et al*., 2015; Pludowski *et al*., 2013). It is also hypothesized that almost all cells in our body are benefitted with vitamin D.

**Vitamin D and bone health:** Vitamin D plays an important role in the regulation of calcium absorption in the body (Veldurthy *et al*., 2016). Therefore, it directly deals with our bone health. Vitamin D deficiency is the main reason of bone weakness, especially in children (Hammer *et al*., 2016). Rickets is a common problem in children due to less sun exposure in developing ages. Low sun exposure or low vitamin D in the diet ultimately affects bone development and growth (Hammer *et al*., 2016). Except rickets, it is also assessed through several research studies that children deficient of vitamin D are more prone of bone fractures even on minor fall (Kaushal *et al*., 2016).

Vitamin D deficiency also plays crucial role in elders. Osteoporosis in elderly people is a common problem worldwide (Vijayakumar and Büsselberg, 2016). In this condition, bones of elderly people become porous and weak and very vulnerable to break. Therefore, hip fractures are very common in elderly people, especially in women after menopause (Svensson *et al*., 2016). Vitamin D deficiency plays an important role in the progression of osteoporosis (Eldash *et al*., 2016) and is the main reason of hip fractures, especially in women (Le Boff *et al*., 1999). Therefore, supplementations of vitamin D and calcium to elderly women reduces the chances of hip fractures (Chapuy *et al*., 1992). In adults, persistent bone and muscular pain along with fatigue known as osteomalacia also attributed to the vitamin D deficiency (Lips *et al*., 2013). According to the guidelines of Myo clinic, muscle weakness and achy bones are signs and symptoms of osteomalacia and could be treated with the proper intake of calcium and vitamin D. Osteomalacia is different from osteoporosis because it may occur in young individuals due to calcium and vitamin D deficiency. Muscular pain, aching, bone weakness and fatigue could be the signs of vitamin D deficiency in elders especially in women (Chalmers *et al*., 1967).

**Vitamin D and hypertension:** An interesting observation was made from epidemiological data that high blood pressure is correlated with geographical location (Kotchen and Kotchen, 1997). People living in higher altitude or away from equator are more prone to have high blood pressure as compared to people living near equator (Holick, 2010).

Sun rays are responsible for the production of vitamin D and also sun rays produces nitric oxide in our body which lowers blood pressure (Feelisch *et al*., 2010; Roméro-Graillet *et al*., 1997). But question still persists here that how vitamin D deficiency is related to high blood pressure? The answer of this question is also very interesting that low

serum vitamin D results elevated levels of parathyroid hormone in the body (Holick, 2007). This hormone is responsible for the elevation of blood pressure (Yao *et al*., 2016). Meanwhile, the elevation of this hormone also increases bone resorption process in which calcium and phosphorus are released from bone to cover body needs therefore bone becomes thickened (Silva and Bilezikian, 2015).

In June 2013, a conference was arranged to gather and analyze the knowledge about vitamin D deficiency and high blood pressure of 35 different studies of 155000 participants from all over the world especially Europe and America. What they found is every 10 % increase of vitamin D in the body leads to 8% decrease in high blood pressure (Kunutsor *et al*., 2013). The reason behind this was found that low vitamin D in the body elevates renin production in the kidney which ultimately affects blood pressure (Wang *et al*., 2016).

**Vitamin D and diabetes:** How vitamin D plays its role in the prevention of onset of diabetes is still in progress but observational studies clearly indicated the relation of diabetes and vitamin D deficiency (Holick, 2007). The studies hitherto found that vitamin D plays a preventive role in the onset of diabetes because beta cells which produce insulin are also sensitive to the vitamin D (Norman *et al*., 1980). The results obtained from animal studies revealed a significant association of preventive effects of vitamin D in type 1 and type 2 diabetes mellitus (Danescu *et al*., 2009).

Finland is a country situated at higher altitude away from equator where sun light comes in very little duration throughout year. An interesting observation was found from Finland that they used more than 4000IU of vitamin D in the infants as supplement before 1960 and the prevalence of type 1 diabetes was very low. But, when they gradually lowered the dose of vitamin D supplementation, they found an exponential increase in type1 diabetes in the children (Mäkinen *et al*., 2014).

**Vitamin D and cardiovascular diseases:** The amazing role of vitamin D on cardiovascular health is now a hot topic of debate among experts. Vitamin D plays its important physiological effects on heart and blood vessels (Ciccone *et al*., 2015). Vitamin D deficiency was also found to be an independent risk factor for cardiovascular diseases (Ciccone *et al*., 2015). Moreover, vitamin D deficiency is correlated with atherosclerosis; a common blood vessel disease in which blood vessels become clogged due to the deposition of cholesterol and other lipids (Faridi *et al*., 2016).

**Vitamin D and brain health:** Vitamin D also affects brain health because brain cells are also benefited with vitamin D (Eyles *et al*., 2005). Therefore its deficiency may cause deleterious effects to the brain (Féron *et al*., 2005). Dementia or loss of memory is a common problem of elder ages. Recently, some studies correlated dementia with vitamin D deficiency (Balion *et al*., 2012). Moreover, it is speculated that vitamin D deficiency is associated with cognitive decline, dementia and other neurodegenerative diseases such as Alzheimer's diseases (Littlejohns *et al*., 2014). Vitamin D regulates the synthesis of nerve growth factor (NGF) which is quite necessary for the proper functioning, development and survival of neurons (Littlejohns *et al*., 2014). Similarly, many researches on other neurological disorders also showed positive correlation with vitamin D deficiency and other neuro degenerative diseases such as Parkinson's disease (Fong *et al*., 2016; Ross *et al*., 2016) epilepsy and Schizophrenia (Yang *et al*., 2016). Scientist also found that maternal vitamin D deficiency causes severe impairments in brain development in gestational period of the fetus in mouse (Overeem *et al*., 2016). In addition some other small scale studies also linked vitamin D deficiency with depression in women (Moy *et al*., 2016; Williams *et al*., 2016).

**Vitamin D and cancer:** Is there any relation between cancer and geographical location? Is there any link between prevalence of cancer and skin color? Scientist were very much surprised to see that different types of cancers are more prevalent in those area which are present away from the equator (Holick, 2010). Most significant findings came out from America where different types of cancers are more prevalent in northern areas as compared to southern areas (Holick, 2010; Kamangar *et al*., 2006). Similarly, it was also found that different types of cancers are more prevalent in the black American as compare to the white American (McIntosh, 1997). The answers of these two questions and observations lead the scientist to unravel the role of vitamin D in the etiology of cancer. At higher altitudes, sun exposure is much lesser than those areas situated near the equator similarly, black American has less tendency to make vitamin D through skin (dark skin color prevents absorption of UVB) as compare to white Americans. More than fifteen different types of cancers were found to be associated with low sun exposure (English *et al*., 1997; Holick, 2010). They include cancers of prostate, breast, colon etc. Prostate cancer is more prevalent in the black peoples as compared to the white and significantly associated with low sun exposure (McIntosh, 1997). According to the findings, people have low vitamin D levels have much aggressive form of prostate cancer (Murphy *et al*., 2014). A review article published in Nature Reviews for Cancer, explained the mechanism through which vitamin D plays preventive role in the onset of breast, colon and prostate cancers (Feldman *et al*., 2014).

**Vitamin D and immune system:** Immune system plays an important role in the prevention and cure of many diseases. Many diseases occur due to the defect or weakness of the immune system. Vitamin D also benefits immune system in a unique way (Svensson *et al*., 2016). One type of immune cells known as macrophages respond well in the presence of vitamin D (Zhang and Xie, 2016). Similarly, researchers found that vitamin D is responsible for the production of a defensive protein cathelicidin in the body (Stukes *et al*., 2016). This protein has broad spectrum anti-microbial activity against bacteria, fungi and viruses (Bikle, 2009). Many studies suggested that low vitamin D levels make a person more susceptible to infections (Kamen and Tangpricha, 2010).

Similarly, it also found that vitamin D plays its beneficial effects in many auto-immune diseases such as rheumatoid arthritis, multiple sclerosis, systemic lupus erythematosus, psoriasis, and inflammatory bowel disease (Holick, 2004). Tuberculosis is one of the most prevalent infectious diseases. Before the discovery of antibiotics, sunlight was effectively used to treat patients of tuberculosis (Koh *et al*., 2013). Lately, it was noted that sunlight is responsible for the production of vitamin D in the body which plays curative role in tuberculosis (Wingfield *et al*., 2014). Vitamin D supplementation plays a beneficial role in the treatment of TB patients (Coussens *et al*., 2012). Those patients who were supplemented with vitamin D along with antibiotics recovered from the disease earlier than the patients which were provided antibiotics only (Wejse *et al*., 2009).

**Vitamin D and women health:** Women are more sensitive in health matters as compared to the male. They have to perform some extra ordinary duties assigned by nature such as creation of a new individual by the process of birth. Therefore, nutrition imbalance makes them more vulnerable of severe disorders. Vitamin D plays a vital role in women health (Bostick *et al*., 1993; Merlino *et al*., 2004; Pittas *et al*., 2006). Research proves that women are found to be more deficient of vitamin D as compared to males (Joshi, 2010). It is due to their living habits and lifestyle. Most of the women use to reside in homes during whole day. They get lesser chances to avail sun light as compared to the males. Meanwhile, Muslim women cover most of their body part when they come out in public. These all factors make them vitamin D deficient. Unfortunately, after menopause, women become more prone to assess the consequences of vitamin D deficiency in the form of bone fractures (Chapuy *et al*., 1992). Therefore, in elder women, bone fractures is a common modality. Researches prove that by maintaining normal vitamin D levels in the body, women can save themselves from fractures of bone after menopause (Chapuy *et al*., 1992).

Vitamin D plays an important role during pregnancy (Hollis, 2016). According to many clinical studies, vitamin D deficiency is more prevalent in the pregnant women and may leads to many complications such as pre-eclampsia, gestational diabetes and most importantly pre-term birth (Holick, 2007). In addition, its deficiency during pregnancy may leads to bone softening of the newly borne babies and this condition is known as rickets (Javaid *et al*., 2006). Vitamin D deficient women have more chances of miscarriage as compared to normal level women (Shand *et al*., 2010). Animal studies showed that vitamin D deficiency causes maternal hypertension, altered placental and fetal developments, and impairments in brain development of newly born babies of mice (Kovacs, 2008). It is therefore, vitamin D supplementation during pregnancy and breast feeding is highly recommended by health authorities worldwide.

**Vitamin D and men health:** Men are made more powerful and having more muscular strength as compared to women. Vitamin D plays essential role for the proper muscular functions in both genders (Pfeifer *et al*., 2002). Vitamin D deficiency may lead to a chronic muscular pain known as fibromyalgia (Holick, 2003). Similarly, vitamin D is essential for stronger bones. Except these, vitamin D possesses its role in male reproductive system. Recently a review article is published in "Nature Endocrinology Reviews" clearly demonstrated the mechanism by which vitamin D plays an important role in the male reproduction by enhancing sperm motility and semen quality (Jensen, 2014). Moreover, some studies also showed that vitamin D increases testosterone levels in the body (Pilz *et al*., 2011). A similar research paper was published in 'Reproductive Biology and Endocrinology', revealed that vitamin D deficiency is significantly associated with low testosterone levels and small size of reproductive organs especially, testis and prostate in Chinese population (Wang *et al*., 2015) .

## CONCLUSION

Vitamin D benefits one's health before birth to the cradle and up to grave. Its deficiency may cause impairments in health and make one's life more vulnerable to be indulged in many diseases such as rickets, arthritis, diabetes, cardiovascular disorders, neuro degenerative diseases and several types of cancers. The real time need is to change life style by taking proper and balanced diet and optimum sunlight exposure (about fifteen minutes a day regularly or one hour on weekly basis). These all thing can make a healthy population, reduce expenses on drugs and make a nation better to serve society and country.

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