Review Article **ISSN: 2581-8015**

International Journal of Nursing and Healthcare Research

Journal home page: www.ijnhr.com

PREVALENCE OF VITAMIN D DEFICIENCY IN TYPE2 DIABETES PATIENTS – AN INTEGRATED REVIEW

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ABSTRACT

Background: Vitamin D deficiency is a global public health concern. Many recent studies indicate that vitamin D deficiency is related to the higher risk of chronic diseases such as coronary heart disease cardiovascular disease (CVD), type 2 diabetes (T2DM), and metabolic syndrome. **Aim:** This article explored the published evidence of prevalence of vitamin D deficiency among type 2 diabetes patients and its effect on glycemic control. **Methodology:** Pub Med, Science direct and Web of science data bases were searched to identify studies published from 2013- 2017 regarding the prevalence of vitamin D deficiency in patients with T2DM. A total of twenty five studies conducted among Type 2 diabetic patients from thirteen countries were included based on the inclusion criteria. **Main findings:** Twenty out of twenty five articles reviewed have revealed the prevalence of vitamin D deficiency in T2DM patients. Two articles that studied the correlation between vitamin D levels and T2DM found that vitamin D levels have an inverse relationship with diabetic markers, such as hemoglobin A1C, fasting blood glucose. Two of the studies could not find a similar correlation. Three case control studies revealed that vitamin D deficiency was found in both cases and controls. **Conclusion:** Thus it can be concluded that, vitamin D deficiency is widely prevalent in type 2 diabetic population globally and it is the need of the hour to identify and treat such deficiencies with can play a major role in glycemic control.

KEYWORDS

Vitamin D deficiency, Type 2 diabetic patients and T2DM patients.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is presently considered as a global health problem and it is reported that about six people die every minute from the disease worldwide (World health organization report, 2016). The International Diabetes Federation (IDF) estimated that 1 in 11 adults aged 20-79 years (415 million adults) had diabetes mellitus globally in

2015 (IDF, 2015)[1] and this estimate is projected to rise to 642 million by 2040. Burgeoning levels of type 2 diabetes (T2DM) pose a worldwide public health crisis, affecting developed and developing countries (Ozfirat and Chowdhury, 2010)[2].

In recent years, vitamin D has been exposed by many research studies, not only to be vital for bone metabolism but also for maintenance and regulation of life-threatening tissues involved in patients with cancer, heart disease and diabetes (Bang-An Luo, Fan Gao, and Lu-Lu Qin, 2017[3], Dimitrios Papandreou and Zujaja-Tul-Noor Hamid, 2015[4], Holick, Binkley, Bischoff-Ferrari, Gordon, Hanley, Heaney and Weaver, 2011[5], Thatcher and Clarke, 2011)[6].

On the basis of cohort studies from developed countries, the relative risk of microvascular disorders and macrovascular disorders among patients with diabetes mellitus was estimated to be at least 10–20 times higher and 2–4 times higher, respectively, than in people without diabetes mellitus (Gregg, Sattar and Ali, 2016)[7]. The symptoms of vitamin D deficiency like pain in the extremities can augment the dangerous effects of vascular complications present in these type 2 diabetic patients. The objective of this Integrated review was to identify the prevalence of vitamin D deficiency among Type 2 diabetes patients and also to create awareness among the health care workers about the importance of vitamin D resources and supplementation on glycemic control in adults with type 2 diabetes mellitus.

BACKGROUND

Vitamin D deficiency is a global public health concern. Many recent studies indicate that vitamin D deficiency is related to the higher risk of chronic diseases such as coronary heart disease cardiovascular disease (CVD), type 2 diabetes, and metabolic syndrome (Athanassiou, Gkountouvas, and Kaldrymides, 2013[8], Chagas, Martini and Rogero. 2012[9], Mitri and Pittas, 2014[10], Pittas, Lau, Hu and Hughes, 2007)[11]. Vitamin D is produced in the body through the exposure of skin to sunlight, which is the main source of vitamin D as the dietary source is minimal (Potenza and Mechanick, 2009)[12]. Factors such as age, season, latitude, time of day, skin pigmentation, amount of skin exposed to sun light, and use of sunscreen can influence vitamin D synthesis (Hashemipour, Larijani, Adibi, Javadi, Sedaghat, Pajouhi, 2004)[13]. Urbanization and less exposure to sunlight, because of social, geographical, and occupational reasons lead to low concentrations of vitamin D (Faghih, Abdolahzadeh, Mohammadi and Hasanzadeh, 2014)[14].

The center for disease control and prevention (CDC) and Institution of medicine (IOM) provide vitamin D level definitions for the general population. Individuals with vitamin D levels between 50 and 75 nmol/L (20–30 ng/ml) are considered to be sufficient. Inadequate levels are in between 30 and lower than 50 nmol/L (12–20 ng/ml), whereas deficiency of vitamin D is less than 30 nmol/L (12 ng/ml). Concern for toxicity is seen at levels greater than 125 nmol/L, which is 50 ng/ml (CDC, 2012[15], IOM, 2011)[16].

In T2DM, research findings have revealed the role of vitamin D from the presence of vitamin D receptors (VDR) in the pancreatic β-islet cells (Garcia-Bailo, El-Sohemy, Haddad, Arora, Ben Zaied, Karmali and Badawi, 2011)[17], which enhances insulin production and secretion through its action on the VDR (Haussler, Jurutka, Mizwicki and Norman, 2011[18], Baeke, Takiishi, Korf, Gysemans and Mathieu, 2010)[19]. A review of the literature from over a decade ago has proposed a relation between T2DM and vitamin D deficiency (Hashemipour *et al.*, 2004)[13]. Recent longitudinal studies have established correlations between low vitamin D levels and the development of type 2 diabetes and also on the opposite continuum where higher levels of vitamin D are associated with decreased incidence of type 2 diabetes (Strange, Shipman, and Ramachandran, 2015[20], Peterson, Tosh, and Belenchia, 2014)[21].

Regardless of the close association of vitamin D levels with T2DM, vitamin D inadequacy is not commonly known as a problem by physicians and other health care workers. More awareness of this problem is essential among researchers, health care workers, and diabetic patients. This under rated vitamin is now known to be playing a vital role in glycemic control of diabetic patients if it can be

maintained between 60 and 80 ng/ml in the body. This deficiency could be due to number of factors like limited sunlight exposure in summer with the use of hats and sunscreen cream, spending lesser time in outdoors for the fear of developing skin cancer, spending more time in the house, office, or in the cars. Additionally aging and darker skin needs longer sun exposure to initiate vitamin D synthesis (Evatt, 2015)[22]. In some religions and cultures, it is required of their people to have their skin covered when they are outside. However, achieving and maintaining the required lifestyle changes is a challenge for many people with diabetes, as they may be suffering from comorbidities of diabetes also. Therefore an integrated review has been conducted as a first step to identify the evidence suggesting the prevalence of vitamin D deficiency among T2DM, and then suggest areas for further research and Interventions for prevention of Vitamin D deficiency among T2DM patients.

PURPOSE OF THE STUDY

The aim of this integrated review was to impress upon the health care workers about the seriousness of the vitamin D deficiency throughout global diabetic population, so that they may take necessary attentiveness to diagnose and treat vitamin D deficiency among patients with Type 2 diabetes. Describing the magnitude of this health problem among T2DM patients will allow operative plans for Vitamin D deficiency prevention and control. Moreover, this review may also aid to recommend the intensity of vitamin D deficiency to the Health ministry, for population based approach of fortification of food items with vitamin D and distributing cost effective supplementation of Vitamin D.

METHODOLOGY

Search strategy

PubMed, Science direct and Web of science data bases were searched to identify studies published from 2013- 2017 regarding the prevalence of vitamin D deficiency in patients with T2DM. Original articles were selected and was then studied critically. We performed a review of studies that evaluated the vitamin D levels among patients of Type 2 diabetes mellitus. We used the value of serum 25OHD as a marker of vitamin D status and HBA1C or Fasting blood sugar as a marker of hospital diagnosed T2DM. Majority of the large-scale population studies of vitamin D have reported the Radio immuno assay method to be excellent in the laboratory to estimate the levels of 25(OH) D levels, and majority of the reviewed studies have used this method.

Inclusion criteria

Studies were included if they fulfilled the following criteria:

1. Studies conducted among Male and Female Adult T2DM patients who are diagnosed at least for a period of one year.
2. Measure of vitamin D status using serum 25(OH)D less than 50 nmol/L or < 20ng/ml.
3. Only English language

Exclusion criteria

1. Studies conducted among T1DM patients.
2. Studies conducted among gestational diabetic mothers.

Data extraction

The extracts of the selected studies were independently reviewed by two reviewers (JRN and ANT). Differences were resolved through discussions. Table were designed to record the details of the studies selected.

Findings

A total of twenty five studies conducted among Type 2 diabetic patients from thirteen countries respectively; Greece – 1, Saudi Arabia – 2, Kuwait – 2, Iraq – 1, Iran – 1, Turkey – 3, Italy – 1, India – 5, UAE – 1, Germany – 1, Ghana – 1, Brazil - 1 and USA – 1. Majority (11) of the studies were cross-sectional studies, 9 of them are case control studies, cohort study – 1, Retrospective studies – 2 and descriptive analysis study – 2. Majority of the studies have measured 25 OHD levels to identify vitamin D deficiency and fasting blood glucose (FBG) or glycated hemoglobin (HbA1C) levels were estimated with regular laboratory methods. Details of all the reviewed studies are presented in Table No.1.

Twenty out of twenty five articles reviewed have revealed the prevalence of vitamin D deficiency in

T2DM patients (Table No.1). Two articles that studied the correlation between vitamin D levels and T2DM found that vitamin D levels have an inverse relationship with diabetic markers, such as hemoglobin A1C, fasting blood glucose. Two of the studies could not find a similar correlation. Three case control studies revealed that vitamin D deficiency was found in both cases and controls.

DISCUSSION

The present review was commenced in an effort to describe the published data on the prevalence of vitamin D insufficiency and deficiency among type 2 diabetic population. Based on the results of studies collected, vitamin D deficiency (<20 ng/ml) was a common finding in patients with type-2 diabetes. Given that majority of the studies revealed an inverse relationship between hemoglobin A1C level and serum vitamin D levels it is believed that low vitamin D levels have an impact on the glycemic control of the T2DM patients. Many recent studies found that vitamin D supplementation has improved glycemic control by increasing insulin secretion (Dutta *et al*., 2014[23], Abbassi *et al*., 2015[24], Mousa *et al*., 2017)[25]. Though we have so much evidence of a role for vitamin D in regulating blood glucose levels, it is still not clear from the studies that, whether vitamin D can prevent, cure, or treat diabetes. Though these are promising reports, clinical trials, or studies on humans, are still needed to prove that vitamin D can prevent or cure diabetes. A meta-analysis of 15 trials by George, Pearson and Witham, 2012[26], did not reveal adequate evidence to recommend vitamin D supplementation for improving glycaemia in patients with diabetes.

Whatever is the argument, it is clear that vitamin D deficiency is prevalent among diabetic population. Few recommendations are put forth to improve the vitamin D status of the T2DM patients. Nurses play an important role to encourage health promotion in the T2DM patients and educating them about the natural sources of vitamin D and as well as available supplementation. The IOM recommends 600 IU/day of vitamin D for individuals aged 9–70 years and 800 IU/day for those > 70 years of age (IOM, 2011)[16]. Vitamin D is found naturally in very few foods like salmon, trout, and sardines, mush-rooms and egg yolk (Center for disease control and prevention, 2012)[15]. From the reviewed articles, it evident that, diabetic patients living in tropical and middle-eastern countries also suffer equally with vitamin D deficiency, where there is abundance of sunlight. This calls for creating awareness about the available sources of this sun shine vitamin through various media. Health education materials could be prepared and distributed in the diabetic clinics and mobile –based applications could be used to spread the information. It is also important to analyze the cultural factors of people living in those countries which can be a hindrance in receiving adequate vitamin D from sun exposure. It has been suggested from a review that, a single exposure to summer sun in a bathing suit for 20 minutes produces the equivalent of 15,000 to 20,000 IU of vitamin D3 (Holick, 2011)[5]. In a study of Hawaiian surfers with sun exposure of at least 15 hours per week for a period of 3 months, 25 (OH) D levels ranged from 11 up to 71 ng/mL, demonstrating wide individual variation (Hollis, Wagner, Drezner, Binkley, 2007)[27], which may be due to various other factors like color of the skin. It is also proved that, outdoor sun exposure and time spent outdoors are better predictors of serum 25 (OH) D values than dietary vitamin D intake (Holick, 2011)[5].

Health care workers have the responsibility to effectively collaborate with the diabetic patient in the assessment and treatment of vitamin D deficiency, which may in turn help in their glycemic control. Recommended dosage of vitamin D supplementation for adults as per the recommendations of Vitamin D Council is 5000 IU of the supplemental vitamin D3 per day in the absence of proper sun exposure (Institution of medicine, 2011)[16]. Ultimately it can significantly improve their quality of life. Therefore, it should be determined whether it is more cost effective to prophylactically recommend vitamin D supplementation to type-2 diabetic patients rather than initiation a screening protocol.

Future Directions

Future research should be carried out to define the clinical role of vitamin D as potential interventions for prevention and management of T2DM. The most

prominent change that could be suggested to current clinical practice standards is the addition of screening type-2 diabetic patients for vitamin D deficiency. Future studies related to vitamin D and type-2 diabetes should focus on determining the most effective dose of vitamin D supplementation needed to treat vitamin D deficiency and insufficiency within this patient population. Moreover, further studies should be done to determine the effectiveness of sun exposure in this population, especially in tropical and middle-eastern countries where the sun exposure is easily possible.

Limitations

Our review has several limitations. Our findings may be affected by few differences in the methodology among the studies like the different laboratory tests done to measure vitamin D levels and HbA1C levels.

Table No.1: Evidence of the reviewed articles

S.No	Author and year	Study Purpose	Study setting	Sample Characteristics	Methodology	Key Findings and Conclusion
1	Shoumera, *et al*., 2013[28]	To assess the vitamin D concentrations and parameters of glycemia in type 2 diabetes and in matched normal controls.	Kuwait	Sixty-nine patients with type 2 diabetes and 60 matched normal control subjects Were studied.	Case control study HbA1C and serum 25(OH)D levels	Patients had significantly elevated fasting glucose (P =0.0001), and HbA1c (P = 0.0005) than the controls had. Patients and controls had similar levels of 25(OH)D, but the levels of 25(OH)D in both were in the deficiency range. Levels of 25(OH)D did not demonstrate any relation with HbA1c,.
2	Athanassiou *et al*., 2013[8]	The aim was to study the relationship between Vitamin D3 levels and glycemic control in patients with diabetes mellitus type 2.	Athens and Pireaus, Greece.	120 diabetes mellitus type 2 patients and 120 normal patients for control.	Case control study 25(OH)D3 levels (HPLC) and glycosylated hemoglobin (HbA1c) levels(RIA)	HbA1c levels being 7.2 ± 0.18 % and 5.1 ± 0.05 % in the patient and control groups, respectively. 25(OH)D3 levels were lower than in the control group, 25(OH)D3 levels being 19.26 ± 0.94 ng/ml and 25.48 ± 1.02 ng/ml in the patient and control group, respectively.
3	Zoppini *et a*l ., 2013[29]	The aim of this study was to determine the correlation between A1C and 25(OH)D in a well characterized cohort of type 2	Italy	715 type 2 diabetic patients. The average age was 68±12 years (range 26-94 years).	Cohort study HbA1C and serum 25(OH)D levels.	Serum 25(OH)D levels were inversely associated with HbA1C levels (r = -0.116, p = .003).

		diabetic patients.				
4	Al-Timimi and Ali, 2013[30]	To investigate the level of 25-hydroxyvitamin D(25(OH)D) in patients with diabetes mellitus (DM) type2 and in those without diabetes.	Iraq	337 Kurd patients with DM type2 and in 146 patients without DM type2.	Case control study HbA1C and serum 25hydroxy (OH) D levels	Patients with poor glycaemic control had a higher prevalence of low vitamin D status (90%) than those with sufficient vitamin D levels (76%). As compared to diabetics with a good and fair glycaemic control, diabetics with a poor glycaemic control exhibited lower 25(OH)D levels ($p<0.01$) and a higher prevalence of low vitamin D status (89% vs. 4% and 7%) respectively.
5	Djalali, 2013[31]	The aim of the present study was to determinevitamin D status among type 2 diabetic patients compared with healthy subjects.	Tehran, Iran	A sample size of 180 subjects including 90 diabetic patients and 90 healthy subjects	Cross-sectional study Serum concentrations of 25(OH)D were measured using chemiluminescence immunoassay (DiaSorin).	The prevalence of vitamin D deficiency was 58.9% in type2 DM patients and 47.0% in healthysubjects. Although the rate of vitamin D insufficiency was higher in the DM patients than the healthy subjects (26.7% versus 24.4%), the difference was not statistically significant ($\chi2 = 0.21$; df = 2;P = 0.89).
6	Alhumaidi *et al.*, 2013[32]	The purpose of the study is to determine the degree of 25-hydroxy vitamin D deficiency in patients with type-2 diabetes mellitus as compared to non-diabetic population	Saudi Arabia	172 in the diabetic group (diagnosed as type-2 diabetes for at least 1 year with HbA1C < 9) and 173 in the non-diabetic group.	Randomized case control study 5-hydroxy vitamin D (25OHD) levels Chemiluminescence immunoassay and HbA1c	The mean serum 25-OH vitamin D levels in the diabetic group were 15.7 + 7.5 ng/mL as compared healthy non-diabetic group having 11.1 + 5.9 ng/mL The population in Southern Region of Saudi Arabia is generally insufficient in 25OH vitamin D irrespective of presence of type 2 diabetes mellitus

7	Zaharani, 2013[33]	To estimate the Prevalence Of Vitamin D Deficiency In Type 2 Diabetic Patients	Riyadh, Saudi Arabia	248 diabetic patients	Cross-sectional study vitamin D level in form of (25 OHD), HbA1c, fasting blood glucose	The great majority of diabetic patients had suboptimal level of vitamin D (98.4%). Almost three-quarters of female diabetic patients (73.6%) compared to male diabetic patients (46.9%) had vitamin D deficiency.
8	Saediosomeolia, 2013[34]	To determine therelationship between serum levels of 25‑hydroxy vitamin D (25‑OH‑D) and glycemic profile in diabetes compared to healthy groups.	Iran	100 patients with type 2 diabetes mellitus (T2DM) and 100 healthy controls.	Cross‑sectional study Fasting serum levels of 25‑OH‑D, glucose, HbA1C.	Eighty‑two percent of type 2 diabetic patients and 75% of healthy subjects were suffering from vitamin D deficiency or insufficiency. Vitamin D deficiency has a high prevalence among Iranian adult population with and without type 2 diabetes.
9	Polur *et al.*, 2013[35]	The aim is to find the association of vitamin D and type2 diabetes mellitus.	Nandhyal, India	120 diabetic subjects aged 35 to 70 years	Case control study vitamin D level in form of (25 OHD), HbA1c, fasting blood glucose	The prevalence of mean levels of Vitamin D deficiency is less in females (36.5%) compared to males (48.2%). Vitamin D shows a significant negative correlation with HbA1c (r= -0.993 P= <0.0001).
10	Gowdaiah *et al.*, 2013[36]	To establish whether patients with type 2 DM have lower levels of vitamin D when compared to that of controls	Bangalore, India	242 subjects were included in the study, of which 139 were cases and 103 controls.	Cross sectional case control study Fasting blood sugar, HbA1c, and 25 OH vitamin D levels.	87% of subjects (i.e. 211 of 242) were having less than optimal levels of vitamin D levels.
11	Cimbek, 2013[37]	The aim was to seek the relationship of vitamin D with other parameters diabetic Patients.	Ankara, Turkey	101 Type 2 diabetic patients and 60 healthy controls	Case control study For the measurements of 25(OH)D, Waters LC-MS/ MS device liquid chromatography mass spectrometry was used and	Results revealed that, vitamin D levels were significantly low in type 2 diabetics compared to nondiabetics. 25 OHD negatively correlated with HbA1C (P=<0.05, R=-0.21).

					Fasting blood sugar.	
12	Bayani *et al*., 2014[38]	The aim of this study was to assess the vit D level in type-2 diabetic patients.	Babol, North of Iran	One hundred-twenty DM patients selected as case group and 120 healthy individuals as control group	Case control study Vitamin D level was measured.	The mean concentration of vit D in the case group was 18.7±10.2 and in the control group was 24.6±13.5 ng/dl (p=0.002). The mean concentration of vit D in male subjects in both groups were equal but in women with diabetes was lower than the healthy women (19.3±11.9 versus 27.03±10.28 ng/dl, respectively) (p=0.0001).
13	Sadiya *et al*., 2014[39]	To report vitamin D status among type 2 diabetes patients (T2D).	UAE	309 individuals with obesity and T2DM	Cross-sectional study Serum concentrations of 25-hydroxy vitamin D (s-25(OH)D), and glycemic profile	VitaminD deficiency was observed in 83.2% of the participants, with a mean s-25(OH)D of 33.8 ± 20.3 nmol/L.
14	Laway *et al*., 2014[40]	The aim of the study was to find the vitamin D status in newly detected T2D patients compared with healthy controls	Srinagar, India	102 newly detected diabetic patients and 102 healthy controls	Prospective case control study serum 25 hydroxy vitamin D (25HD)	Overall 25HD, was lower (mean ± SD, 18.81 ± 15.18 ng/ml) in patients with T2D as compared to healthy controls (28.46 ± 18.89 ng/ml) (P = 0.00).
15	Fondjo *et al*., 2015[41]	This study sought to provide information on vitamin D status among Ghanaian type 2 diabetics.	Ghana	118 clinically diagnosed Type 2 Diabetes Mellitus (T2DM) patients and 100 healthy non-diabetic patients	Case control study Fasting blood sugar and 25OHD by ELISA.	There was vitamin D deficiency of 92.4% among T2DM cases and 60.2% among the non-diabetic controls.
16	Mauss *et al*., 2015[42]	Aim of the study was to explore the association of vitamin D levels in diabetic patients with healthy working adults older than 45 years.	Germany	1821 employees of a German engineering company (83.1% male, mean age 51.9 ±5.6 years).	Cross-sectional study Vitamin D levels and fasting plasma glucose (FPG) and glycosylated hemoglobin (HbA1c).	Severe vitamin D deficiency (<10 ng/ml) was associated with increasing FPG (β 3.13; 95%CI: 0.78, 5.47; p≤0.01) and HbA1c (β 0.15; 95%CI: 0.08, 0.23; p≤0.001) values in

						adjusted linear regression models.
17	Serdar Olt, 2015[43]	This study investigated the impact of vitamin D on glycemic control in patients with type 2 diabetes mellitus.	Turkey	128 patients with type 2 diabetes mellitus	Cross-sectional study Vitamin D (25[OH] D) levels, HbA1c	The vitamin D deficiency rate was 98.3%. In the result with ROC curve analyzes and Mann Whitney U test vitamin D was'nt significantly associated with good and poor glycemic control (P value >0.05).
18	Sheth *et al*., 2015[44]	The aim is to examine whether 25-hydroxyvitamin D (25OHD) has clinically significant influence on hemoglobin glycation (HbA1c) in T2DM subjects.	Ahemedabad, India	912 subjects (429 T2DM cases and 483 non-diabetic controls)	Prospective cross sectional study FBS, PPBS, HbA1c, and 25OHD levels in blood.	Vitamin D deficiency was seen in 91.4% and 93.0% of T2DM cases and control subjects respectively. vitamin D deficiency is prevalent in T2DM and non-diabetic subjects, its role in hemoglobin glycation could not be established
19	Usluogullari *et al.*, 2015[45]	To investigate the frequency of 25-OH vitamin D deficiency in type 2 diabetes mellitus.	Turkey	Medical records of 557 patients with type 2 diabetes and 112 healthy controls	Retrospective study 25-OH vitamin D, HbA1c	No significant difference in serum 25-OH vitamin D concentrations was observed between the diabetic and control groups. No correlation was observed between HbA1C and serum 25-OH vitamin D levels.
20	Zhang *et al*., 2016[46]	The aim of the study was to report findings from the first national survey in Kuwaiti adults of vitamin D status and its association with the prevalence of diabetes	Kuwait	960 adults	Cross-sectional study Serum 25(OH)D concentration was analyzed on a Cobas e601 immunoassay analyzer. Fasting glucose and HbA1C levels.	About one-fourth (25.5 %) of the Kuwaiti adults had diabetes and one-third (33.9 %) had prediabetes. serum concentration of vitamin D was significantly lower in pre-diabetic and diabetic participants (39.6 and 39.8 ng/ml) than nondiabetic participants (42.9 ng/ml, p = 0.01).
21	Rolim *et al*., 2016[47]	To determine the prevalence of hypovitaminosis D	Bahia, Brazil	108 patients with mean duration of	Cross sectional study 25-hydroxyvitamin	The prevalence of hypovitaminosis D was 62%.

		in patients with type 2 diabetes mellitus (T2DM)			D [25(OH)D] and HbA1c levels	
22	Heidari *et al*., 2016[48]	Evaluation of vitamin D deficiency in the patients with type 2 diabetes in comparison with the control group is the purpose of this study.	Iran	100 type 2 diabetes patients and 100 healthy controls	Descriptive analytical study Vitamin D (25-Hydroxy vitamin D) using enzyme immunoassay method and HbA1C.	Out of all the diabetes patients, 91% suffered from vitamin D deficiency or insufficiency and only 9% had normal vitamin D level. Vitamin D serum level was 19.35/ 15.84 ng/ml in the case group and 22.50 /15.66 ng/ml in the control group.
23	Almetwazi *et al*., 2017[49]	To identify the vitamin D deficiency among patients with diabetes.	USA	The study population included a total of 929 diabetic adult persons.	Cross –sectional study HbA1C Levels and Levels of 25(OH)D3	About 57% of patients with diabetes had a vitamin D deficiency.
24	Kumar *et al*., 2017[50]	This study evaluates the correlation between Vitamin D status and Glycated Hemoglobin in Type 2 Diabetes Mellitus.	Pondychery, India	78 diabetic cases and 69 controls	Retrospective case control study Vitamin D levels and Glycated Hemoglobin	The mean Vitamin D values in cases were 16.1 ng/ml and in controls were 17.3 ng/ml. Though the mean values of Vitamin D in cases were lower than that of controls, the difference was not statistically significant (p=0.31). Spearman correlation showed there was no statistically significant correlation between Vitamin D levels and Glycated hemoglobin (p value 0.741).
25	Mahmodinia *et al*., 2017[51]	The aim is to investigate the frequency of vitamin D deficiency in type 2 diabetes patients.	Iran	101 type 2 diabetes in Shahrekord, Iran	Descriptive-analytic study Serum vitamin D by DRG (USA) Elisa kits.	The average age of the subjects was 61.25±11.75 years. Around 72 subjects were vitamin D deficient.

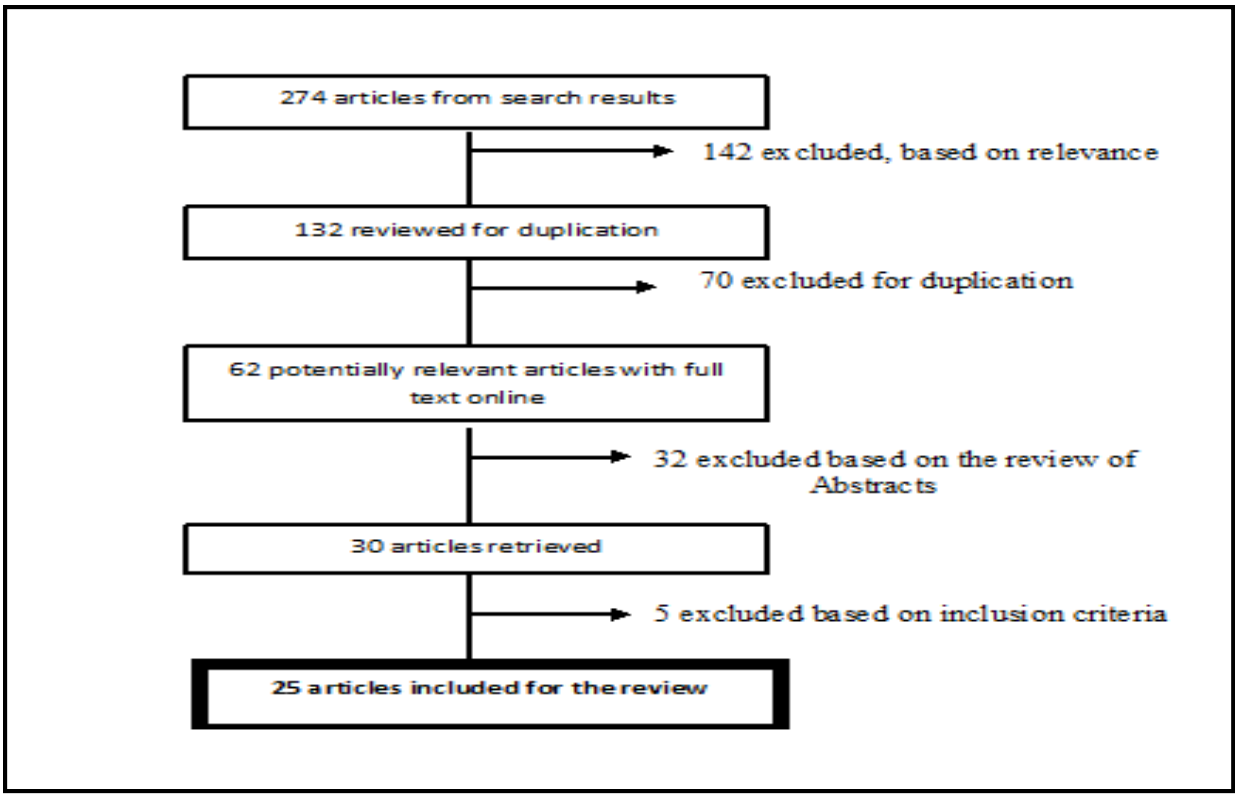

Figure No.1: Methodological flow chart

CONCLUSION

Vitamin D is crucial not only to maintain bone strength, but the review suggested its vital role in glycemic control in T2DM patients. Based on the literature review, over 20 studies showed that type-2 diabetic patients are more likely to have vitamin D deficiency and insufficiency compared to the general population. Thus it can be concluded that, vitamin D deficiency is widely prevalent in type 2 diabetic population globally and it is the need of the hour to identify and treat such deficiencies with can play a major role in glycemic control.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to Fundamentals and Administration, College of Nursing, Sultan Qaboos University, Muscat, Oman for providing necessary facilities to carry out this review work.

CONFLICT OF INTEREST

No conflict of interest was identified.

SOURCE OF FUNDING

Study has not received any funding.

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Please cite this article in press as: Jansi Rani Natarajan and Anitha Nesa Thanka. Prevalence of Vitamin D deficiency in Type2 diabetes patients - an integrated review, *International Journal of Nursing and Healthcare Research,* 2(1), 2018, 1-14.