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An Update on Vitamin D: The Role in Chronic Disease, Clinical Practice Implications, and the Current Status of Nurse Practitioner Knowledge

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Sara E. Robertson, Student

Dr. Dorothy Brockopp, Advisor

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and the Current Status of Nurse Practitioner Knowledge

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Dedication

This capstone project is dedicated to the people who have supported me throughout this process. I would like to dedicate this work to my dear friend and colleague Whitney Nash for her support. Additionally, I would like to dedicate this work to both my darling Gracie and Liane for inspiring me.

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I would like thank my committee Kathy Hager and Sharon Lock for their support throughout this process. I would especially like to thank my committee chair Dorothy Brockopp for her time and patience. Her advice will not only help me be a better clinician and researcher but most importantly will help me to better teach others.

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Introduction to the Final DNP Capstone Report

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In the late 20th century there was very little focus on low vitamin D levels as a health concern. With the introduction of vitamin D fortified milk and food products in the 1950's, medical clinicians believed that vitamin D deficiency was no longer a health concern. However, after the turn of the century research examining vitamin D levels in adults demonstrating that a large portion of the United States population was vitamin D deficiency. This discovery lead to hundreds of studies in the last decade which aim to figure out the role of vitamin D in overall health and determine what clinical consequences occur in a deficient state. Vitamin D deficiency has now been associated with many acute and chronic conditions.

Specifically, the first manuscript in this capstone report focuses on the connection between Vitamin D deficiency and Type 2 Diabetes (DM2). Although a cause and effect relationship between vitamin D deficiency and increased risk of DM2 is still elusive, many studies have demonstrated an association between the two chronic disease states. A Literature Review from 2009 examining 12 articles demonstrated that patients who are diabetic are more likely than the general population to have vitamin D deficiency. Additionally, individuals who were deficient in vitamin D are more likely to get DM2 and to get the disease at an earlier age. Finally, diabetics who are concurrently vitamin D deficient have poorer control of sugar levels. This research indicates that vitamin D deficiency may play a role in the development and treatment of DM2, however, more research is needed to examine that role.

The second manuscript in this capstone reviews the current clinical knowledge regarding vitamin D deficiency. This article begins with the definition of vitamin D insufficiency and deficiency and its correlation to chronic disease states. Next, the risk

factors and epidemiology of vitamin D deficiency are discussed. Finally the article summarizes the latest information on appropriate clinical screening and treatment of vitamin D deficiency.

The third manuscript in this capstone series details a research study completed in 2012 to determine the knowledge level of nurse practitioners regarding vitamin D deficiency. A survey was distributed to nurse practitioners at a national conference. The results indicate that nurse practitioners overall have poor knowledge of vitamin D deficiency. Nurse practitioners are expected to make critical decisions regarding patient care and it is important that they have a good understanding of vitamin D deficiency ensuring that they can appropriately treat patients. The results of this study indicate that more education is needed regarding vitamin D deficiency and its connection with chronic disease.

The Association between Vitamin D Deficiency and Type 2 Diabetes Mellitus:

A Systematic Review

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Abstract

Purpose: Type 2 Diabetes Mellitus (DM2) is a leading cause of morbidity and mortality and vitamin D deficiency may promote poor glucose metabolism. This systematic review examines the relationship between vitamin D deficiency and DM2.

Data Sources: An electronic search of articles published from 2005 to 2012 in CINAHL, PubMed, Medline, EBSCO, Cochrane Library, EMBASE, and Pascal was performed.

Conclusion: Cohort studies show a relationship between low vitamin D status and prevalence of DM2. Inverse correlations exist between low vitamin D status and β-cell insulin secretion, insulin resistance, and fasting plasma glucose levels. Studies are limited because of the cross-sectional design, poor follow-up, and lack of adjustments for confounders. Two intervention studies show mixed results, but they include sub-therapeutic doses of vitamin D and small sample sizes. Case studies demonstrated a 12% decrease in sugar levels. The current evidence suggests that vitamin D does play a role in effective glucose metabolism; however, more controlled intervention trials are needed to fully explain this relationship.

Implications for Practice: Screening and treatment of vitamin D deficiency could help in the prevention or treatment of DM2. Screening and treatment can prevent complications and improve quality of life in a cost effective manner.

The Association between Vitamin D Deficiency and Type 2 Diabetes: A Systematic Review

Background

The incidence of type 2 diabetes mellitus (DM2) is increasing at a disturbing rate in the United States. According to the Centers for Disease Control (CDC), the prevalence of DM2 is estimated at 25.8 million people or 8.3% of the population (Center for Disease Control, 2011). Diabetes is the 7th leading cause of death, and also contributes to the development of heart disease, stroke, high blood pressure, neuropathy, blindness, and kidney disease. The CDC estimates the costs of diabetes and its associated morbidities to be $174 billion but the immeasurable cost is in the loss of quality of life and the premature death that commonly occur with the disease. DM2 is a result of genetics and lifestyle factors such as diet and exercise but is primarily associated with obesity (Chagas, Borges, Martini, & Rogero, 2012). Given that weight loss is difficult to achieve and maintain it is essential that other potentially modifiable risk factors for type 2 diabetes be examined. One potential risk factor that is currently being investigated is the occurrence of sub-optimal serum vitamin D levels. The purpose of this article is to systematically review the association between vitamin D and type 2 diabetes mellitus, and explore the possibility that enhancement of serum vitamin D to a prescribed level, may augment current diabetes treatment and prevention strategies.

Vitamin D is a fat soluble vitamin which is dependent on consumption from foods that are naturally rich in the vitamin or fortified such as fish, eggs, and milk. Additionally, vitamin D can be synthesized under ultra-violet (UV) exposure in the skin (Bohaty, Rocole, Wehling, & Waltman, 2008). Both methods provide the body with a precursor vitamin that is converted to the active form of vitamin D via the liver and the

kidney. Once it appeared that rickets (associated with a lack of vitamin D) was a disease of the past, many health providers did not give much recognition to vitamin D or the implications of vitamin D deficiency. However, recently studies started emerging that demonstrate large portions of the population suffers from hypovitaminosis D (Holick, 2007). A large cross-sectional cohort study that analyzed data from the National Health and Nutrition Examination Survey (NHANES III) determined that 50.73% of all women tested were deficient in vitamin D. This number increased to 72.46% when examining Hispanic women (Zadshir, Tareen, Pan, Norris, & Martins, 2005). A second study by Yetley examined data from the National Nutrition Monitoring System which determined a 30% prevalence of vitamin D deficiency at the current standard and a 70% deficiency when analyzed against a proposed higher standard vitamin D level (2008). Additionally, females were more likely to have a greater deficiency then males in all ages except children ages 1-5. Yetley also found that vitamin D levels have an inverse relationship to body mass index (BMI). Furthermore, it appears that vitamin D deficiency can occur even in people that live in sunny climates and are consistently exposed to the sun's UV rays. A study performed in Arizona found that even with a history of adequate sun exposure, deficiency occurred in 25% of the population studied (Jacobs et al., 2008). This study also provided data that reinforced increased prevalence in women, Hispanics, Blacks, and obese individuals.

The most well-known function of vitamin D is to maintain calcium and phosphorus homeostasis; however, the discovery that most cells on the body have a vitamin D receptor suggests that the vitamin could have many more functions within the body (Holick, 2012). Sub-optimal vitamin D is associated with multiple musculoskeletal

disorders including osteoporosis and osteoporosis related fractures, muscle pain, weakness, and increased risk of falls (Binkley, 2012; Haroon & FitzGerald, 2012). Additionally, vitamin D deficiency has been linked to several different forms of cancer including colon, prostate and breast cancer (Mitchell, 2011). It has even been suggested that vitamin D can also have an influence on common age-related morbidities including dysphagia, urinary incontinence, and cognitive decline (Binkley, 2007). More recently, evidence suggests that sub-optimal serum vitamin D levels may play a role in the development of DM2. Evidence indicates that vitamin D may have a direct role in insulin secretion and the utilization of insulin by peripheral tissue. It is hypothesized that binding of circulating 1,25-dihydroxyvitamin D (the active form of vitamin D) to the pancreatic β-cell vitamin D receptor promotes insulin secretion (Peechakara & Pittas, 2008). Additionally, the regulation of calcium levels by vitamin D can also indirectly promote β-cell insulin secretion by maintaining a consistent flux of calcium into the cell. Finally, it also appears that vitamin D stimulates the expression of insulin receptors on target-tissues which facilitates the uptake and use of insulin (Penckofer, Kouba, Wallis, & Emanuele, 2008).

Methods

An electronic search was conducted to identify studies that were published from 2005 to 2012 in the following databases: CINAHL, PubMed, Medline, EBSCO, Cochrane Library, EMBASE, and Pascal. Articles were limited to English language. Focus was placed on cohort and case control studies, as well as randomized controlled trials (RCT) that examined the relationship between vitamin D deficiency and DM2. Because metabolic syndrome has the same risk factors as DM2 and is a known precursor,

data examining the link between vitamin D and metabolic syndrome were also investigated. Keywords used were: type 2 diabetes, DM2, metabolic syndrome, vitamin D deficiency, hypovitaminosis D, β-cell function, and insulin resistance. Nine articles were retrieved via the electronic search method. An additional three articles were found while reviewing the references to those articles and other literature reviews on the topic. The total number of articles reviewed was 12.

Inclusion/Exclusion Criteria

For inclusion to the systematic review, articles needed to focus on the relationship between vitamin D and DM2 or metabolic syndrome. Because there were relatively few randomized controlled trials, well designed cohort and case control studies were also reviewed. Because there are so few studies that have examined the relationship between vitamin D deficiency and DM2, all levels of evidence were included in the review. Studies were critiqued by the Center for Evidence Based Medicine's evidenced based practice score. Limitations to each study, especially those that are lower levels of evidence, are addressed in the results section. Studies that examined DM2 in children and those that focused on type 1diabetes were excluded because of the variation of insulin metabolism in children and the varied pathology and cause of type 1 diabetes. Studies that examined vitamin D deficiency in relation to other chronic health problems such as renal disease, gastro-intestinal malabsorption syndromes, and parathyroid gland pathologies were also excluded. Finally, studies where the primary subject focus was pregnant women or women who were breast feeding were also excluded due to the additional nutritional demands that occur in those unique physiologic states which could affect serum vitamin D levels, requirements, and intake.

Results

In 2004, Chiu et al. were the first to directly measure insulin secretion and insulin sensitivity and relate those to serum vitamin D levels. The results demonstrated that vitamin D levels had a negative correlation with fasting plasma glucose levels and a positive correlation with the insulin sensitivity index (ISI). These associations remained after adjusting for age, sex, ethnicity, BMI, waist to hip ratio, systolic and diastolic blood pressure, and season ($p < .0001$). This important study indicated that vitamin D seems to be an independent factor in proper beta cell function and insulin sensitivity, two important factors in the development of DM2. Since the release of that study there has been increased interest in the relationship between vitamin D levels and type DM2.

There are very few randomized controlled intervention trials examining the relationship between vitamin D and DM2. Therefore, the bulk of the evidence on this relationship has been demonstrated through cohort studies. Of the cohort studies reviewed there were four cross-sectional studies, one retrospective study, and four prospective studies. In all of the cohort studies one outcome that was consistent was that women had an increased prevalence of vitamin D deficiency over men. When examining the relationship between vitamin D and DM2 the results are inconsistent.

In the largest cross-sectional study to date, 8,241 individuals (see table 1 for characteristics of cohort studies) from the National Health and Nutrition Examination Survey (NHANES), a random, national cohort, were examined to determine the relationship between their vitamin D level and risk of having metabolic syndrome (Ford, Ajani, McGuire, & Liu, 2005). After adjusting for multiple confounders, vitamin D influenced risk of metabolic syndrome. The odds of having metabolic syndrome

decreased with each increasing quintile of vitamin D level (OR .85 - .38). Another cross-sectional study looked at a non-diabetic population from the Framingham Offspring Study (Liu et al., 2009). The results were similar to the NHANES study suggesting that an increased vitamin D level is associated with decreased risk factors for DM2. More specifically subjects in the higher tertile of vitamin D levels had a 1.6% lower fasting plasma glucose, 9.8% fasting insulin secretion, and a 12.7% lower insulin resistance score than subjects in the lowest tertile. This relationship remained after adjustments for confounding factors.

In 2009, Wehr et al. also looked at the risk of metabolic syndrome based on vitamin D status in a population of women with polycystic ovary syndrome (PCOS). This study reinforced the data from the previous study that the odds of having metabolic syndrome increases with decreased vitamin D levels. Results suggested an inverse relationship between vitamin D levels and fasting and stimulated glucose levels, insulin resistance based on the homeostatic model assessment (HOMA-IR), insulin secretion based on the homeostatic model assessment (HOMA-β), and C-reactive protein (CRP). This study is limited by adjustments for only age, BMI, and season. However, the consistency of the findings is still suggestive of a significant relationship between vitamin D and DM2.

Only one cross-sectional cohort study found no significant relationship between vitamin D levels and DM2 (Snijder et al., 2006). However, there are several limitations to the study. One main limitation was that the only outcome measured was incidence of DM2 which may not be as sensitive as measuring direct physiologic changes in insulin secretion and uptake. Additionally, the average age of the population studied was 75yo ±

6.5 years. This homogenous elderly population is not a representative sample of the general population.

There were four prospective cohort studies reviewed. In 2006, data from the Nurse's Health study were reviewed (Pittas et al.). Results stated that women who consumed >800 IU of vitamin D or more daily had 23% lower risk of DM2 compared with women who consumed < 200 IU per day. The risk ratio (RR) was .87; however, after adjustments for confounding variables the results were not significant ($p = 0.67$). Limitations of the study included a poor follow-up rate (5%) and an almost homogenous sample of Caucasian females. In another study, data were examined from the 1958 British Birth Cohort (Hypponen & Power, 2006). All subjects were born in 1958 and were 45 years old at the time of data collection in 2003. Hemoglobin A1C (HbA1C) was measured as an outcome to this study. Results demonstrated that increased vitamin D levels were associated with decreased HbA1C ($p<0.0001$).

A prospective cohort study which looked at a random sample of men and women in Finland, demonstrated at the higher quartile of vitamin D level verses the lowest quartile an inverse relationship between vitamin D levels and risk of DM2 (RR=.70) (Mattila et al., 2007). However, after adjustments for confounding variables the results did not remain significant at $p =.07$. Finally, a study of 524 non-diabetic men and women did demonstrate a significant relationship between vitamin D levels and diabetes associated factors (Forouhi, Luan, Cooper, Boucher, & Wareham, 2008). Results indicated that increased levels of vitamin D were associated with a lower 10-year risk of hyperglycemia, lower insulin levels, and decreased insulin tissue resistance (HOMA-IR) independent of confounders.

In one retrospective study that was reviewed, a convenience sample of post-menopausal women, was studied (Need, O'Loughlin, Horowitz, & Nordin, 2005). The results suggested that vitamin D level influenced fasting glucose levels independent from age and BMI. This relationship was strongest in women who had vitamin D levels that were by definition deficient or < 20ng/mL. The authors inferred that since increased fasting glucose levels are a direct indicator of metabolic syndrome and DM2 by implication it was determined that vitamin D levels play a role in poor glucose metabolism.

Of the cohort studies reviewed there were six that demonstrated a relationship between vitamin D levels and DM2 or one of the significant factors known to play a role in the development of diabetes. Two studies initially demonstrated a significant relationship but significance did not remain after adjusting for confounding factors. Finally, one study did not show any relationship. Many of the cohort studies were plagued by poor follow-up, homogenous populations, and outcomes that are influenced by multiple factors. These cohort studies suggest that future research on the topic of vitamin D deficiency is warranted.

There are only two RTCs that examine the relationship of vitamin D and factors that can contribute to metabolic syndrome and DM2. In one study, 314 Caucasian adults who did not have diabetes received either 500 mg of calcium citrate and 700 IU of vitamin D or placebos daily for three years (Pittas, Harris, Stark, & Dawson-Hughes, 2007). Participants were divided into two groups at baseline representing those with normal glucose metabolism and those with impaired fasting glucose (IFG) levels. The two groups were matched with controls for age, weight, and physical activity score.

There was a higher percentage of "never smokers" in both intervention groups 53% to 42% in the normal glucose subgroup and 36% to 32% in the IFG subgroup. The study showed a significant increase in vitamin D levels in both of the intervention groups. There was no significant difference in fasting plasma glucose levels, CRP, interleukin-6 levels, or incidence of DM2 between either of the intervention groups and their respective placebo groups. However, in the IFG subgroup insulin resistance measured by HOMA-IR increased significantly more in the placebo group than in the group that was taking vitamin D. In the normal glucose group there was no difference in insulin resistance. This study demonstrated a greater effect of vitamin D on the impaired group. Limitations to this study include a relatively small sample size, a homogenous sample, and the intervention included vitamin D and calcium supplementation rather than vitamin D alone.

The second RCT was from the Women's Health Initiative study. In one arm of the study, randomly assigned postmenopausal women received 1000mg of elemental calcium and 400 IU of vitamin D daily while the control group received a placebo in a double-blinded fashion (de Boer et al., 2008). After a mean follow-up time of seven years 2,291 women were diagnosed with diabetes. The hazard ratio for incidence of diabetes between groups was 1.01 demonstrating a null result. There have been several noted limitations to this study. One major limitation was that there was no certainty that the control group did not take vitamin D either within a multivitamin or as a supplement. Because of the double-blinded fashion control subjects were not instructed to refrain from taking any supplemental vitamin D. Additionally, the amount of vitamin D used in the

intervention (400 IU) is a small dose that does not tend to affect overall serum vitamin D levels.

Evidence from the RCTs suggests that there is an association between vitamin D and insulin resistance; however, there was not an association between vitamin D and each of the other outcomes tested. Both RCTs have significant limitations and based on the results of the previous cohort studies more RCTs are needed to help determine the exact relationship between vitamin D and DM2.

Finally, an article detailing two specific case studies was reviewed (Schwalfenberg, 2008). One case study detailed a 63-year-old African American diabetic who had an unchanging A1C of 8.4% on oral medications diet and exercise. After it was determined her vitamin D level was severely deficient, she was started on vitamin D replacement therapy at 2000 IU for two months and then 3000 IU for nine months. After taking vitamin D for 6 months her HbA1C was reduced to 7.4%. The author also reported that the patient experienced a greater number of hypoglycemic episodes and consequently reduced her metformin dose from 500mg three times a day to twice daily. Finally, the patient actually reported that she exercised less in the 6 months that she was on vitamin D therapy, but her weight remained stable and her diabetes improved. The second case study examined a 71-year-old white female with long term diabetes treated with several oral medications. With an A1C of 13.3%, it was recommended that she start insulin; however, the patient refused. Around the same time her vitamin D deficiency was discovered. After nine months of vitamin D repletion and no other change in her diabetic treatment regimen at 2000 IU per day, her HbA1C level

was reduced to 12.2%. In both case studies the dependent variable of vitamin D repletion resulted in an average decrease in blood sugar levels of 12%.

Optimal Intake of Vitamin D in Relation to Type 2 Diabetes

According to Holick and Chen (2008), Vitamin D deficiency is currently defined as <20 ng/mL of serum 25-hydroxyvitamin D [25(OH)D] which is the major circulating form of vitamin D. Levels <30 ng/mL 25(OH)D are considered insufficient. The threshold of 30ng/mL was determined to be adequate because above those levels bone undergoes proper mineralization eliminating rickets. However, the recent discovery of vitamin D receptors on almost every cell in the body including breast, prostate, muscle, pancreatic and immune cells has prompted researchers to reexamine the minimum acceptable level (Holick, 2007). Currently the Institute of Medicine (IOM) recommends that children and adults up to 50 years old should receive 400 IU of vitamin D daily and adults over age 70 need 600 IU, as well as 15 minutes of direct unprotected sunlight to the hands and face every day (Institute of Medicine, 2010). These recommendations are based on the 30ng/mL threshold to prevent rickets. According to Vieth et al. (2007) studies are suggesting that higher levels of vitamin D intake are necessary to prevent other pathologies associated with vitamin D including preventing cancer, reducing fractures and reducing risk of chronic diseases such as diabetes. Specifically studies that have examined fracture prevention have demonstrated decreased risk of fracture with vitamin D levels up to 40ng/mL (Bischoff-Ferrari, Giovannucci, Willett, Dietrich, & Dawson-Hughes, 2006). One recent study examined participants who were consistently exposed to a sun-rich environment and women who were on taking 6400 IU of vitamin D_3 daily (Hollis, Wagner, Drezner, & Binkley, 2007). In both the natural and

supplemented vitamin D groups levels peaked between 40 to 60ng/mL and additional sunlight or supplementation did not increase levels further. This indicates that an optimal therapeutic range of vitamin D could be higher than the current standard. As for optimal vitamin D levels and type 2 diabetes specifically, there is not enough data currently to suggest an optimal level; however, the current best evidence indicates that vitamin D levels of <20 ng/mL were associated with increased risk factors for metabolic syndrome and DM2. Future research should evaluate serum vitamin D levels of 40 - 60ng/mL to determine if higher serum levels result in better patient outcomes.

When examining the current evidence, particularly the RCTs, it is important to understand the amount of vitamin repletion necessary to make a meaningful impact on vitamin D levels. For example the small dose (400 IU) given to women in the Women's Health Initiative Study has only been shown to increase blood levels of vitamin D by 4 ng/mL over a six month period of time (Heaney, Davies, Chen, Holick, & Barger-Lux, 2003). Vitamin D dosed at this level is sub-therapeutic, especially in a deficiency state, and would not be expected to produce meaningful outcomes. A recent study that addressed prescribing regimens for vitamin D repletion found that >600,000 IU of Vitamin D_2 supplementation given for a mean of 60 days was necessary to achieve sufficiency in 64% of cases. There were no reports of vitamin D toxicity (Pepper, Judd, Nanes, & Tangpricha, 2009). Experts suggest that in future intervention trials a substantial dose of 2000 IU per day is needed to raise vitamin D to optimal levels to truly explore its role in the prevention or attenuation of DM2 (Vieth et al., 2007).

Gaps and Future Research

Currently there are several gaps in the research regarding vitamin D deficiency and the presence of DM2. The most obvious gap is the lack of well-constructed intervention trials with controls. These trials need to have larger sample sizes and provide a vitamin D dose that is high enough to increase serum vitamin D levels above 40ng/mL. Additional cohort studies are also needed to confirm the effect of vitamin D repletion on the two direct pathologies in DM2: β-cell insulin secretion and peripheral uptake of insulin. These well controlled studies are also necessary to determine if vitamin D is truly a contributing factor to the development of DM2 or merely a marker for overall poor health.

Additionally, further research is needed to determine if the effects of vitamin D repletion occur across ethnic populations. The prevalence of vitamin D deficiency is highest in darker skinned individuals including black and Hispanic populations. Studies that look at genetic polymorphisms or variation can help determine why there is ethnic variation in the processing of vitamin D from sunlight and help determine risk. These populations are known to be at the highest risk for diabetes. Both intervention and cohort studies are needed to determine the effects of vitamin D in the prevention or in the treatment of DM2 in those special populations.

Finally, more research is needed to determine the best repletion practices as well as the optimal serum level of vitamin D. Many experts believe that the current standard of 30ng/mL is too low; however, there is currently not enough research to establish a different standard. Suggestions for optimal levels range for 40ng/mL to 80ng/mL. With concentrated repletion regimens (> 600,000 IU) that lasted a mean of two months, only

64% of cases achieved sufficient values greater than 30ng/mL. Additional research could determine a more consistent time frame and daily or weekly regimen to increase the success rates of vitamin D repletion.

Conclusion

Most diets in the United States do not provide sufficient vitamin D intake to maintain adequate serum levels. In addition to poor intake, decreased sun exposure, increased use of sunscreen and genetic variations in the conversion of the sun's UV rays to vitamin D are all causes of vitamin D deficiency. Providers need to be aware that women, individuals with darker skin pigmentation, and those who are obese are at higher risk for vitamin D deficiency. Vitamin D deficiency has been associated with many chronic conditions including DM2. Specifically the evidence suggests that vitamin D influences β-cells secretion of insulin and ameliorates insulin resistance. The outcome of these effects is an inverse relationship between vitamin D and HbA1C, fasting plasma glucose levels and incidence of metabolic syndrome. The possibility that a relatively inexpensive vitamin can help delay onset or assist with the treatment of DM2 has a number of public health implications. Clinicians should consider testing high-risk individuals for vitamin D deficiency and supplement deficient patients, especially those with DM2. Further research is necessary to determine the true impact of this cost-effective and widely available intervention.

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Table 1

General characteristics of cohort studies relating DM2 and vitamin D

First Author/Yr	Cohort	Outcome Measure	Results	Adjustments for confounding factors	Comments
Wehr et al. (2009) (cross – sectional)	Females with PCOS Mean age: 29 n=206	1 and 2 hr gtt; HOMA – IR[1]; HOMA – β[2] QUICKI[3]; CRP[4]	- Vit. D prevalence = 72.8% - Inverse correlation b/t vit. D and fasting and stimulate glucose levels, HOMA-IR, HOMA- β and fasting and stimulated insulin, and CRP	Season, BMI, and age	No control group; low vitamin D levels are associated with features of metabolic syndrome
Forouhi et al. (2008) (prospective)	Random non-diabetic men and women ages 40-69yo n=524	2 hr gtt; insulin; metabolic syndrome risk z score; HOMA-IR;	- Women lower vit. D than men - Vitamin D inversely associated with 10- year risk of hyperglycemia, 2h-gtt, HOMA-IR, and metabolic syndrome risk	Age, sex, smoking, BMI, season and baseline metabolic variable	Higher vit. D is assoc. with lower future glucose, insulin, and HOMA-IR. Independent of confounders
Liu et al. (2008) (cross-sectional)	Non-diabetics from Framingham Offspring Study n=808	2 hr ggt; insulin, HOMA-IR; ISI[5]; plasma adiponectin	-vitamin D inversely associated with waist circumference and BMI -positively associated with ISI, adiponectin and HDL -higher tertile of vit D had 1.6% lower fasting glucose; 9.8% lower fasting insulin; 12.7% lower insulin resistance score	Age, sex, BMI, waist circumfe-rence, smoking status	Positive assoc. not significant after adjustments; vit D and 2 hr gtt was not significant; vit. D associated with increase in DM2 risk markers even in nondiabetics
Matilla et al. (2007) (Prospective)	random men and women from Finland n=4,079	Incidence of DM2	-inverse association of vit. D levels and risk of DM2 -RR 0.60 (p=0.01) between highest quartile vitamin D and lowest -further adjustment attenuated to RR	Age, sex, season then also BMI, exercise, smoking,	Decreased RR of DM2 with higher serum levels of vitamin D although relationship is

			= .70 (p=.07)	education	attenuated after confounding
Hypponon et al. (2007) (Prospective)	Random men and women in England all 45 yo n = 7,198	HbA1C[6]	-HbAIC decreased with increased vit. D levels up to 30ng/mL - HbA1C in deficient vit. D group – 5.4%; sufficient group 5.1%	sex, season, geography, exercise and social class	Association was greater in obese subjects
Pittas et al. (2006) (Prospective)	Random women from the nurse's health study with 20 year f/u n=83,779/4843	Incidence of DM2	-women who consumed > 800 IU or more of daily vitamin D intake had 23% less lower risk of DM2 compared with women who consumed <200 qd with RR .87 (p=.67)	Age, BMI, exercise, family history DM2, smoking, ETOH, coffee, diet, HTN, calcium intake	No history of diabetes, CVD, or cancer at baseline Risk decreased further when vit. D intake combined with increased calcium intake Non-significant p-value
Snijder et al. (2005) (cross-sectional)	Men and women from Amsterdam n=1,235	Incidence of DM2	-no significant association in incidence of DM2 and vitamin D levels	Age, sex, waist to hip ratio, exercise, smoking, ETOH, season	Mean age of participants was 75yo ± 6.5 years which may have influenced results
Need et al. (2005) (retrospective)	Convenience sample of post-menopausal Females n=753	Fasting plasma glucose	-Vitamin D inversely related to fasting glucose level. (p<.001) -Greatest increase was in those with a vit. D < 16ng/mL	Age, BM	Fasting serum glucose increased as vit. D levels decreased
Ford et al. (2005) (cross-sectional)	Males and females from NHANES III	Incidence of DM2 and fasting plasma	The odds of having metabolic syndrome decreased with each increasing quintile of vitamin D level.	Age, sex, race, exercise,	Vitamin D still seemed to influence risk of DM2 even

	N=8,241	glucose level	OR .85 - .38	ETOH, smoking, diet, vitamin use, cholesterol, CRP, education, season	after adjusting for confounders

1.HOMA-IR: Homeostatic model assessment – Insulin Resistance 2. HOMA-β: Homeostatic model Assessment – β-cell secretion 3. QUICKI: Quantitative insulin sensitivity check index 4. CRP: C-reactive protein 5. ISI: Insulin sensitivity index 6.HbAIC: Hemoglobin A1C

Update on Vitamin D Deficiency:

Clearing Up the Confusion for Nurse Practitioners

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Abstract

Purpose: To provide an update on vitamin D for nurse practitioners. Media Reports and conflicting information result in confusion regarding the screening, diagnosis and management of vitamin D. The physiology of vitamin D, definitions of vitamin D deficiency, risk factors for deficiency, and population statistics are reviewed. Screening and treatment recommendations are also reviewed, including the recommended daily allowance of vitamin D, sun exposure, and supplementation strategies.

Data Sources: Clinical studies, literature review articles, consensus guidelines, and the Institute of Medicine (IOM) recommendations.

Conclusions: Although there is disagreement regarding the definition of vitamin D deficiency, recent literature confirms the following information. Risk factors include poor dietary intake, decreased sun exposure, darker skin pigmentation, genetics and obesity. Vitamin D deficiency is common. Vitamin D repletion involves increasing dietary intake, limited sun exposure, and vitamin D supplementation. For most individuals vitamin D supplementation is a necessary component of repletion and maintenance. High-dose vitamin D_2 (50,000IU) and vitamin D_3 can be used safely and effectively.

Implications for Practice: Given that treatment of vitamin D deficiency is known to promote bone health and is likely to enhance immune response and decrease morbidity, understanding of appropriate screening, diagnosis, and management of vitamin D deficiency is essential for the nurse practitioner.

Key words: vitamin D deficiency; hypovitaminosis D; vitamin D supplementation

What is Vitamin D?

When the minimum dose of vitamin D to prevent rickets was recognized, many healthcare providers did pay attention to vitamin D or the implications of vitamin D deficiency. In recent years, however, studies emerged demonstrating that large segments of the United States (US) population suffer from vitamin D deficiency or hypovitaminosis D (Holick, 2007). Vitamin D is a fat-soluble vitamin which is dependent on oral consumption from foods that are naturally rich in the vitamin or fortified, such as fish, eggs, and milk or vitamin D supplementation. Additionally, vitamin D can be synthesized under ultra-violet (UV) exposure in the skin (Bohaty, Rocole, Wehling, & Waltman, 2008).

Vitamin D from food, supplements, and sun exposure is biologically inert and must undergo two hydroxylations before it is biologically active. Vitamin D is first metabolized in the liver to 25-hydroxyvitamin D [25(OH) D3] also known as calcidiol. Next, calcidiol is metabolized in the kidneys into 1,25-dihydroxyvitamin D [$1,25(OH)_2D$] also known as calcitriol. Calcitriol is the active from of vitamin D. This conversion is tightly regulated by plasma parathyroid hormones and serum calcium and phosphate levels (Holick & Chen, 2008). Because, calcitriol, has an extremely short half-life, it does not offer an adequate reflection of vitamin D status; therefore, the intermediary form of vitamin D, 25(OH)D or calcidiol, is routinely checked via serum concentration to determine vitamin D status. Vitamin D, 25(OH)D has a half-life of 15 days. Serum measurement of 25(OH)D does not reflect the amount of vitamin D that is stored in body tissues, mainly adipose tissue (Hollis, Wagner, Drezner, & Binkley, 2007)

What is Vitamin D Deficiency?

Controversy exists regarding the definition of vitamin D deficiency and insufficiency. Two organizations, The Endocrine Society and the Institute of Medicine (IOM), differ in their definitions for vitamin D levels. The traditional definitions of normal, insufficient, and deficient vitamin D, as defined by the Endocrine Society, are as follows (the unit ng is currently used in current practice and lab reports):

Vitamin D deficiency: Serum 25OHD less than 50nmol/mL **(20ng/mL)**

Vitamin D insufficiency: Serum 25OHD between 50 – 72.5nmol/mL **(20-29ng/mL)**

Vitamin D sufficiency: Serum 25OHD more than 75nmol/mL **(30ng/mL)**

These figures were determined by examining the relationship between vitamin D and serum parathyroid hormone (PTH). PTH is increased when vitamin D is low suggesting a positive feedback; however, when serum Vitamin D levels reach 30ng/mL to 40ng/mL parathyroid hormones level off. Additionally, with an increase in serum vitamin D levels from 20ng/mL to 30ng/mL calcium absorption from the gut is increased from 45% to 65% (Holick et al., 2011).

In November of 2010 the IOM released a report on the status of vitamin D in the United States. The following are their definitions of normal and inadequate vitamin D levels as defined by the IOM (the unit ng is used in current practice and lab reports):

At risk of vitamin D deficiency: Serum 25OHD less than 30nmol/L **(12ng/mL)**

At risk of vitamin D inadequacy: Serum 25OHD 30–49nmol/L **(12–19ng/mL)**

Sufficient in vitamin D: Serum 25OHD 50–125nmol/L **(20–50ng/mL)**

(Institute of Medicine, 2010)

These numbers were determined by examining the relationship between vitamin D levels and bone health. The IOM states that a serum vitamin D level of 20ng/mL is what is necessary for healthy bone development. The IOM did not consider vitamin D levels in association with other disease states other than bone health for the establishment of the current norms. Because of the sole focus on bone health, these new standards were met with contention from providers in specialist communities such as endocrinology, rheumatology, and oncology (Heaney & Holick, 2011; Maxmen, 2011).

What About Vitamin D and Other Diseases Besides Bone Health?

Even though the IOM report did not find sufficient evidence to definitively associate vitamin D with disease states other than poor bone health, many studies are suggesting that these associations could become more clear in the future. Vitamin D is known to be the primary regulator of over 600 crucial genes. Additionally, the discovery that most cells in the body have a vitamin D receptor suggests that the vitamin could have many more functions within the body than previously thought (Holick, 2007). Vitamin D has been found to be crucial for a healthy immune system and deficient states are associated with higher rates of reactivated tuberculosis (Hewison, 2010). A study performed at the Mayo Clinic in Minnesota, found that 93% of patients whose chief complaint was nonspecific musculoskeletal pain were deficient in vitamin D (Plotnikoff & Quigley, 2003). Vitamin D deficiency has been linked as a risk factor, as well as, a factor in treatment to several different forms of cancer including colon, prostate and breast cancer (Mitchell, 2011; Spina et al., 2006). Furthermore, it has been suggested that vitamin D can also have an influence on common age-related morbidities including

falls, dysphagia, urinary incontinence, and cognitive decline (Binkley, 2007; Bischoff-Ferrari, Giovannucci, Willett, Dietrich, & Dawson-Hughes, 2006).

Evidence also suggests that vitamin D deficiency may play a role in the development of type 2 diabetes mellitus (DM2). Vitamin D may have a direct role in insulin secretion and the utilization of insulin by peripheral tissue. It is hypothesized that binding of circulating 1,25-dihydroxyvitamin D (the active form of vitamin D) to the pancreatic β-cell vitamin D receptor promotes insulin secretion (Peechakara & Pittas, 2008). Additionally, the regulation of calcium levels by vitamin D can also indirectly promote β-cell insulin secretion by maintaining a consistent flux of calcium into the cell. Finally, it also appears that vitamin D stimulates the expression of insulin receptors on target-tissues which facilitates the uptake and use of insulin (Penckofer, Kouba, Wallis, & Emanuele, 2008).

What Are the Risk Factors for Vitamin D Deficiency?

Risk for vitamin D deficiency is multifaceted and can include non-pathologic factors such as dietary intake, sun exposure, race, genetics, and obesity. Pathologic risk factors for vitamin D deficiency (which are beyond the scope of this report) include liver failure, nephritic syndrome, chronic kidney disease, and diseases of the parathyroid gland.

Nutrition

As demonstrated in table 2, only a few foods supply a noteworthy amount of vitamin D. Of those foods, fish and cod liver by far contain the greatest amount of vitamin D. A lack of fresh fish can be an issue in many parts of the country (especially the Midwest) where fish is not fresh and therefore is not part of daily or even weekly diet.

Unfortunately fatty fish that is high in vitamin D, can also contain high levels of mercury which would limit the intake for pregnant women. Additionally, conditions such as lactose-intolerance limit the intake of milk and other dairy products. Due to the fact that most foods have very little vitamin D and dairy products are poorly tolerated by some individuals, diet is generally regarded as a poor source for vitamin D (Holick, 2011). Finally, vitamin D is poorly transferred via breast milk. When breast milk is the sole source of nutrition, infants are at high risk for vitamin D deficiency (Hollis & Wagner, 2004).

UV Light Exposure

Considering the minimal impact of diet on vitamin D status, ultra-violet (UV) light exposure from the sun is a primary and sufficient source of vitamin D. Due to the consistent findings, however, of low vitamin D levels throughout the United States population the importance of sun exposure in maintaining adequate vitamin D levels is being called into question (Adams & Hewison, 2010). Melanin is the pigment that is primarily responsible for skin color. Highly pigmented skin does not absorb vitamin D as well as skin with less melanin. Vitamin D is synthesized in the skin by the action of UV-B. High melanin content in the skin reduces UV-B exposure and consequently cuts the conversion of 7-dehydrocholesterol (7-DHC) to pre-vitamin D which is the first step in a chain of reactions that ends in active vitamin D (Hollis et al., 2007). As global immigration becomes more prevalent, individuals with high skin melanin content are living at higher latitudes. The decrease in sun intensity found at higher latitudes and in more seasonal climates, impacts the ability to synthesize an adequate amount of vitamin D from sunlight and results in higher rates of vitamin D deficiency in individuals with

darker skin pigmentation. It has been demonstrated that even with significant, long-term sun exposure populations with darker skin have decreased levels of vitamin D (Binkley et al., 2007; Nesby-O'Dell et al., 2002; Sahu et al., 2009).

Use of Sunscreen

Topical sunscreen agents interfere with the exposure of skin to UV-B radiation, thereby decreasing the amount of UV-B converted to pre-vitamin D. The higher the sun protection factor (SPF) the more that the sunscreen, by definition, will decrease UV-B exposure (Tsiaras & Weinstock, 2011). There are very few studies that have measured the effect of sunscreen use on vitamin D levels.

Study results on the use of sunscreen and vitamin D differ. One study, completed in 1988, found that serum vitamin D levels were 64% lower in 20 individuals who were habitual sunscreen users than their 20 sun-exposure matched control subjects (Matsuoka, Wortsman, Hanifan, & Holick). However, a randomized controlled trial in Australia, noted little difference between placebo and control groups in relation to the effect of sunscreen use on serum vitamin D levels (Marks et al., 1995). With this mixed information it is difficult to determine the role sunscreen use plays in vitamin D deficiency. It has been suggested that typical sunscreen use may play only a minimal role considering that most individuals apply less than the suggested, effective amount of sunscreen initially and only 43% of individuals reapply at regular intervals (American Academy of Dermatology, 2008).

Genetics

Genetics is also an emerging factor in the development of vitamin D deficiency. After examining genetic profiles of various groups of Hispanic and African Americans

and analyzing serum vitamin D levels, Engelman et al. found that polymorphisms in the vitamin D binding protein (VDP) gene do exist and in some cases were associated with lower levels of serum vitamin D (2008). As with many other disease states, genetics is an emerging field and further studies are needed to confirm if certain genetic mutations can lead to vitamin D deficiency.

Obesity

Obesity is another risk factor in the development of vitamin D deficiency. Vitamin D is readily absorbed by adipose tissue and is saved for subsequent release and metabolism when there is a need during the winter months. However, when there is a larger pool of adipose tissue, the sequestration of vitamin D is associated with poor bioavailability (Holick, 2007). Therefore, levels of vitamin D in obese individuals tend to be 57% lower than their age-matched, normal weight controls (Wortsman, Matsuoka, Chen, Lu, & Holick, 2000).

What is the Epidemiology of Vitamin D Deficiency?

Many studies have determined that large segments of the United States population are either insufficient or deficient in vitamin D. A large cross-sectional cohort study that analyzed data from the National Health and Nutrition Examination Survey (NHANES III) determined that mean levels of 25(OH) D3 were lower in Latinos and African Americans than their white counterparts. Additionally, women had lower levels of vitamin D across all age ranges and races (Zadshir, Tareen, Pan, Norris, & Martins, 2005). This study determined that 34% of white men and 45% of white women had insufficient levels of vitamin D. Insufficiency rates were even higher in minority populations. Seventy-six percent of Latino men and 77% of Latino women were

insufficient while 55% of black men and 72% of black women had inadequate levels of vitamin D. Even though sun-exposure can impact and sometimes improve vitamin D levels, several studies demonstrate that even in sun-rich areas inadequate levels of vitamin D is still pervasive in the population. Jacobs et al. states that even in sun-rich Arizona 25% of the population is deficient in vitamin D (<20ng/mL). When identifying subjects who are insufficient and deficient (<30ng/mL), the percentage increases to 76%. Again, minorities have higher rates of insufficiency and deficiency than their white counterparts. While 75% of whites were either insufficient or deficient, 87% of Latinos and 88% of Blacks were lacking adequate vitamin D (2008). A study that examined subjects in sun-rich Florida determined that 39% of their overall study population was deficient in vitamin D compared with 25% in the Arizona study (Levis et al., 2005). In a study performed in sun-rich Honolulu, Hawaii, it was found that 51% of the 93 university students tested had low vitamin D status (Binkley et al., 2007).

What is the Current Dietary Allowance of Vitamin D?

Even though there is overwhelming evidence that indicates that large segments of the United States populations, and especially the darker-skinned minority populations, have low levels of vitamin D, the IOM stated in their report that most North Americans have sufficient intake of vitamin D to support bone health (Institute of Medicine, 2010). As stated previously the IOM determined that currently there is not enough scientific evidence to definitively link vitamin D to other diseases such as cancer, diabetes, rheumatologic conditions or increased risk for infection; therefore, adequate levels of vitamin D for the prevention of other pathologies were not considered in the recommendations. Even though the committee stated that most individuals have

sufficient intake of vitamin D, by current standards, they recommended that the Food and Nutrition Board increase the recommended daily allowance (RDA) of vitamin D for adults ages 18-70 years old from 400IU to 600IU per day. These types of inconsistencies have fueled further criticism of the IOM report. Medical providers have challenged the homogeneity of the committee members, the institute's consistent recommendations for the entire North American population regardless of race or residential latitudes, and many disagree with the IOM's sentiment that with few exceptions, all North Americans are receiving enough vitamin D (Maxmen, 2011; Plotnikoff, 2011).

Who Should be Screened for Vitamin D Deficiency?

The IOM report did not provide any recommendations regarding the screening of vitamin D. By increasing the recommended daily intake level, the committee suggested that all individuals that consume 600IU of vitamin D per day will maintain blood levels greater than the 20ng/mL needed for bone health (Institute of Medicine, 2001). The Endocrine Society, however, does suggest in their guidelines that individuals at high risk for deficiency should be screened (Holick et al., 2011). Because of its longer half-life, the intermediary form of vitamin D, calcidiol, or 25(OH)D, should be the only lab test used for the screening of serum vitamin D (Hollis et al., 2007).

What is the Best Way to Treat Vitamin D Deficiency?

The IOM report provided little structure for vitamin D repletion in the case of vitamin D deficiency. Patient education regarding appropriate food intake is an important factor in the treatment for vitamin D deficiency. However, most foods provide only a small amount of the recommended dietary intake of vitamin D. Additionally,

barriers such as lack of personal taste for fish, cost of fish, mercury content, and dietary intolerances make dietary changes challenging.

Because there are a limited number of foods that contain significant amounts of vitamin D and prolonged sun exposure is associated with an increased risk of skin cancer, vitamin D supplementation is a safe and effective method of achieving adequate serum levels (American Academy of Dermatology, 2008). According to the Endocrine Society guidelines, most high-risk individuals will need vitamin D supplementation to achieve and maintain sufficient serum levels of vitamin D (Holick et al., 2011). The IOM report suggests that the goal for treatment be lowered to 20ng/mL, whereas, the Endocrine Society report recommends that patients maintain a level of 30ng/mL to 50ng/L. Finally, the IOM report recommends 60ng/mL as the upper threshold of safe serum vitamin D levels (Institute of Medicine, 2010). At levels above 60ng/mL it is unknown what potential negative or adverse effects may occur.

There are two different forms of vitamin D supplementation currently available on the market, vitamin D_2 or ergocalciferol and vitamin D_3 or cholecalciferol. Vitamin D_2 is obtained from plant material and enters the circulation via the same pathway as supplemented foods. Vitamin D_3, while also taken orally, is more similar to 7-dehydrocholesterol that is formed when UV light enters the skin (Stechschulte, Kirsner, & Federman, 2009). Vitamin D_3 is also found in natural fish sources such as cod liver oil, salmon, mackerel, and herring. Studies demonstrate that both vitamin D_2 and vitamin D_3 have similar capacity to increase serum vitamin D levels (Cannell, Hollis, Zasloff, & Heaney, 2008). Vitamin D_2 is available by prescription only. It is a high dose capsule, 50,000IU, which allows for weekly dosing and is only useful in the treatment of deficient

states. Conversely, vitamin D_3 which is available over-the-counter, provides variable dosing from 200IU to 4000IU. This type of dosing is traditionally more useful in daily maintenance or treatment of mild insufficiency.

Most traditional regimens for vitamin D repletion include several weeks of high-dose therapy (either once weekly or three times a week for 4 to 12 weeks) and then maintenance on lower dose therapy. In 2008, Pepper et al. evaluated a variety of repletion regimens that included only vitamin D_2. The study concluded that regimes which contained at least 600,000IU of vitamin D_2 appeared to be the most effective in treating vitamin D deficiency and that the actual regimen of how this was achieved was inconsequential. In 2011, Papaioannou et al. challenged the traditional regimen in a study of 65 elderly, hip-fracture patients with low vitamin D. The subjects were randomized into 3 treatment groups. The groups differed only by the bolus amount of vitamin D given at the start of therapy. One group was placebo and did not receive a bolus while the second and third groups received a one-time bolus of 50,000IU and 100,000IU of vitamin D_2 respectively. After the one-time bolus dose all three groups were given 2,000IU of vitamin D_3 to take daily for 90 days. Surprisingly, the results of the serum 25(OH)D levels, demonstrated no difference among the three groups. This suggests that high (bolus) doses of vitamin D_2 may not always be necessary for vitamin D repletion.

There is not one method to treating vitamin D deficiency. Further studies are needed to determine if weekly high-dose therapy or daily low-dose therapy is best for repletion. It appears that vitamin D repletion by any method should be successful;

therefore, the nurse practitioner should consider patient compliance and patient preferences regarding high-dose versus low-dose regimens.

Conclusion

There are still many inconsistencies and controversies surrounding vitamin D deficiency which can be very confusing for the nurse practitioner. Achieving goals of serum 25(OH)D levels of greater than or equal to 30ng/mL will not cause harm to the patient and may have increased benefit over a maintenance level of greater than 20ng/mL. Patients who are at high-risk for vitamin D deficiency should be screened. There is no consensus on "best-practice" repletion strategies; however, use of vitamin D_2 and/or vitamin D_3 seem to be equally effective in mitigating deficiency and do not appear to cause harm as long as serum 25(OH)D levels stay below 60ng/mL. Nurse practitioners should be aware of the risk factors for vitamin D deficiency, screen high risk patients, and initiate a treatment and maintenance regimen to sustain a sufficient state.

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Table 2

Sources of vitamin D

Food	**IUs per serving**
Cod liver oil (1 tbsp).	1,360
Salmon (3oz)	447
Mackerel (3.5oz, cooked)	345
Sardines (1.75 oz, canned)	250
Tuna fish (3 oz, canned)	200
Milk (1cup, fortified)	117
Orange juice (1 cup, fortified)	100
Cereal (1 cup, fortified)	100
Margarine (1 tbsp, fortified)	68
Egg (1whole)	41
Swiss cheese (1 oz)	18

IU = International Unit
(Institute of Medicine, 2010)

Vitamin D Knowledge among Nurse Practitioners

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Abstract

Purpose: To explore Nurse Practitioner (NP) knowledge of vitamin D and vitamin D deficient states and appropriate testing, risk factors, and treatment of low levels of vitamin D.

Data Sources: A descriptive, exploratory survey of 100 NPs at a national conference. A 17 item questionnaire included four main sections: demographic information, knowledge items, and treatment of vitamin D as well as a question on frequently used sources for information on vitamin D.

Conclusions: NP knowledge of vitamin D is inconsistent to poor. NPs were able to consistently identify a limited number of risk factors for low vitamin D. Identification of the appropriate lab testing occurred 59% of the time and NPs identified laboratory result thresholds for diagnosis only 51% of the time. Almost 40% of NPs did not know that vitamin D could reach toxic levels in the body. Only 2% of NPs were able to accurately identify the current recommended daily allowance of vitamin D for adults and only 16% identified the correct RDA for the elderly. NPs were unaware that several chronic diseases have been associated with low vitamin D. Even though vitamin D supplementation was commonly used for treatment, the recommended dosage and frequency of treatment varied greatly.

Implications for Practice: It is crucial that NPs have the knowledge they need to assess and treat vitamin D deficiency. Maintaining adequate vitamin D levels is a cost-effective way to prevent or adjunctively treat many chronic diseases. NPs need additional education on the diagnosis and treatment of vitamin D deficiency.

Key words: vitamin D deficiency; hypovitaminosis D; vitamin D supplementation

Vitamin D Knowledge among Nurse Practitioners

Background

Vitamin D is a fat soluble vitamin that is most recognized for its role in bone health where deficiency results in rickets/osteomalacia due to poor calcium absorption in the gut (Binkley, 2012). Decreased vitamin D levels are sub-divided into 2 categories, insufficiency and deficiency, and are defined by the Endocrine Society as follows the unit ng is used in current practice and lab reports:

Vitamin D deficiency: Serum 25OHD less than 50nmol/mL (20ng/mL)

Vitamin D insufficiency: Serum 25OHD between 50 – 72.5$nmol/mL (20-29 ng/mL)

Vitamin D sufficiency: Serum 25OHD more than 75nmol/mL (30ng/mL) (Holick et al., 2011).

Risk factors for vitamin D deficient states include: poor intake of dietary vitamin D, lack of ultraviolet (UV) light exposure, darker skin color, use of sunscreen, genetics, and obesity (Engelman et al., 2008; Holick, 2007).

Vitamin D is known to be the primary regulator of over 600 crucial genes. In addition most cells in the body have a vitamin D receptor suggesting that the vitamin could have many more functions in the body than previously thought (Holick, 2012). Recent evidence suggests that vitamin D deficiency could play a role in the development of all types of diabetes due to its roles in insulin secretion and the utilization of insulin by peripheral tissue (Takiishi, Gysemans, Bouillon, & Mathieu, 2012). Vitamin D deficiency

is also linked to several forms of cancer including colon, prostate and breast cancer (Mitchell, 2011; Spina et al., 2006). Vitamin D deficiency has also been associated with increased cardiovascular risk; decreased immune response to infection; increased risk of autoimmune disease and cognitive decline (Balion et al., 2012; Hewison, 2012; Muscogiuri et al., 2012).

It has been demonstrated that large sections of the US population maintain low levels of vitamin D. A large cross-sectional cohort study that analyzed data from the National Health and Nutrition Examination Survey (NHANES III) determined that mean levels of 25(OH) D3 were lower in Latinos and African Americans than their white counterparts. Additionally, women had lower levels of vitamin D across all age ranges and races (Zadshir, Tareen, Pan, Norris, & Martins, 2005). This study determined that 34% of white men and 45% of white women had insufficient levels of vitamin D. Insufficiency rates were even higher in minority populations. Vitamin D levels were insufficient in 76.2% of Latino men and 77% of Latino women while 55% of black men and 72% of black women also had inadequate levels of vitamin D. Even though sun-exposure can impact and sometimes improve vitamin D levels, several studies demonstrate that even in sun-rich areas inadequate levels of vitamin D are still pervasive in the population. Jacobs et al. (2008) states that even in sun-rich Arizona 25% of the population is deficient in vitamin D (<20ng/mL). When identifying subjects who are insufficient and deficient (<30ng/mL) the percentage increases to 76%. Again, minorities have higher rates of insufficiency and deficiency than their white counterparts. While 75% of whites were either insufficient or deficient, 87% of Latinos and 88% of Blacks were lacking adequate vitamin D (2008). Another study that examined subjects in sunny

Florida determined that 39% of their overall study population was deficient in vitamin D compared with 25% in the Arizona study (Levis et al., 2005). In a study performed in sun-rich Honolulu, Hawaii, it was found that 51% of the 93 university students tested had low vitamin D status (Binkley et al., 2007).

According to the American Association of Nurse Practitioners, 89% of the 140,000 nationally licensed Nurse Practitioners (NPs) are prepared in a primary care focus (adult, family, gerontology, pediatric or women's health) (2013). With current reports stating that such large portions of the population have low levels of vitamin D, it is likely that the nurse practitioner provider will need to recognize and treat patients with low vitamin D. It is important to ascertain the current level of knowledge of NPs regarding recognition, diagnosis and treatment of vitamin D deficient states. This includes knowledge of risk factors for vitamin D deficiency, appropriate lab testing and interpretation, as well as treatment options. It is crucial that NPs have the knowledge they need to effectively manage low vitamin D in order to mediate risk of poor bone health, musculoskeletal pain, and many chronic disease states.

Purpose

The purpose of this study was to explore NP knowledge of vitamin D and vitamin D deficient states as well as appropriate testing, risk factors and treatment of low levels of vitamin D.

Methods

Design, Study Sample and Data Collection Procedures

In this descriptive, exploratory study, a cross-sectional survey approach was used. After obtaining permission from the American Association of Nurse Practitioners

(AANP), surveys were made available to nurse practitioner attending the AANP 2012 national conference in Orlando, Florida. Questionnaires were placed on a table in the hallway of the convention center. The investigator stood beside the table and asked nurse practitioners if they would be willing to respond to the survey. Questionnaires were returned to a sealed collection box near the table. One-hundred and fifty six surveys were distributed and collection was stopped when the number of completed and returned forms reached 100. Participation was limited to actively practicing nurse practitioners. Students and nurse practitioners who were not actively practicing were excluded from the study.

Instrument

The investigator designed survey was developed using: a) an extensive review of the literature and b) current guidelines issued by the Endocrine Society regarding vitamin D (Holick et al., 2011). The 17 item questionnaire includes four main sections: demographic information, knowledge items, two questions on treatment and a single question on identifying resources used by nurse practitioners to learn about vitamin D deficient states. The demographic section includes four questions. The knowledge items consist of both multiple choice items and one question that required participants to rank answers in order. Initially the knowledge survey was a total of ten questions and included four questions on laboratory testing and interpretation of laboratory results, two questions on risk factors for vitamin D deficiency, one question on vitamin D content in foods and sunlight, two questions on recommended daily intake levels of vitamin D by the Food and Drug Administration (FDA), and one question on vitamin D and associated chronic conditions. However after statistical analysis the knowledge survey was reduced

to six questions. The two questions pertaining to risk factors, the question on sources of vitamin D and association of vitamin D with chronic conditions were eliminated from the final knowledge assessment. Each question contained multiple parts and all parts needed to be correct for the entire question to be considered correct. The four questions were eliminated because the number of correct answers to those questions was so low that those questions were not useful in delineating NP knowledge. Before the elimination of the questions the highest NP knowledge score was 6 points out of 10 which was also the case after the elimination of the questions. Additionally, the nature of the questions (needing to get multiple parts within the question correct to achieve an overall correct response) proved to be too challenging for most participants. Even though the four questions were not used in the total knowledge score, participant responses were analyzed and results reported below.

Human Subjects and Research Approval Procedures

Prior to data collection all research team members met institutional researcher training requirements and the study protocol gained approval as exempt research by the University of Kentucky Institutional Review Board (IRB). As approved by the IRB survey participants were informed in a preamble statement that their participation implied consent and that no identifying information would accompany their survey submission.

Data Analysis

The Statistical Software for the Social Sciences (SPSS) version 20.0 was used to analyze data. Both inferential and descriptive statistics were used to analyze data. Descriptive statistics included frequencies, means, standard deviations, and ranges. Comparisons and associations were calculated using independent t- tests and Pearson

product moment correlations. Results were reported as significant when a threshold of $p < 0.05$ was met.

Results

Of the 100 participants in this sample 70% were nurse practitioners certified in family practice. Four other specialties were also represented. Length of practice as a NP was reported $\underline{M} = 9.77$ years ($SD = 8.26$) with a range of <1 to 40 years (see Table 3). Eighty percent of the participants reported evaluating and treating vitamin D deficiency in their practice.

Participant knowledge on vitamin D was based on answers to 6 multiple choice questions. Scores ranged from zero to six with six representing the greatest knowledge (see table 4). The mean knowledge score of nurse practitioner respondents was 2.30 ($SD = 1.31$). The t-test for independent samples indicated a significant difference in the mean knowledge score between nurse practitioners who reported assessing and treating vitamin D deficiency in practice ($t=2.903$, $p<.05$, $M=2.49$, $SD=1.27$) compared to those who do not regularly assess vitamin D ($M=1.55$, $SD=1.23$). No difference was found in the mean knowledge score when comparing Adult NP/Family NP versus other represented specialties ($p=.670$). An examination of NP years of practice revealed a small correlation that was not significant ($r=.086$, $p=.413$).

Each knowledge score component was analyzed by frequency of correct versus incorrect answer (see Table 5). Only 59% of respondents were able to identify the correct laboratory test used to determine serum vitamin D levels. Only 51% and 41% of respondents were able to identify the correct serum laboratory threshold for vitamin D insufficiency and deficiency, respectively. When asked about vitamin D and toxicity,

only 61% responded correctly that vitamin D can reach levels of toxicity which could potentially be fatal. Finally, only 2% of respondents knew the current recommended daily allowance (RDA) of vitamin D for adults and on 16% could identify the current RDA for elderly individuals greater than 70 years old.

Four questions that were separated from the knowledge score asked participants about risk factors for vitamin D deficiency, sources of vitamin D, and chronic diseases associated with vitamin D deficiency (see Table 6). When participants were given a list of seven potential patients and asked to identify the risk of that patient having vitamin D deficiency, their mean score was 3.64 (SD 1.33, ranger 0-7). Respondents were most likely to misidentify two types of patients: a) Latino males who work outdoors and b) 3 month old Caucasian infants who are exclusively breastfed both of whom are high risk. The patients who were more likely to be identified correctly were Latina woman who work indoors and Caucasian women who work a desk job both of whom are also high risk. Only 2 of the respondents were able to identify the correct risk status for all 7 potential patients.

When participants were given a list of patient characteristics and asked to identify which of the characteristics indicate high risk or low risk for vitamin D deficiency, respondent's mean score was 4.71 (SD 1.0, range 0-7). The most common characteristics that participants misidentified were: having brown or olive skin tone (high risk), having white skin tone with freckles (low risk), and having dark black skin (high risk). Most of the respondents were able to correctly identify that little sun exposure and obesity were both high risk characteristics for vitamin D deficiency. None of the respondents were able to correctly identify all seven risk variables.

When given a list of sources of vitamin D and asked to rank them in order from best to least participants overall did very poorly. Most participants only ranked one or two items in the correct order (M=1.56, SD 1.54, range 0-7)

Participants were also asked about specific chronic diseases and their association with vitamin D. All of the diseases on the list have been associated with low vitamin D status. It is important to note that little research has investigated causality between low vitamin D and these chronic diseases; however, in all cases patients with these chronic diseases are found to have an increased incidence of vitamin D deficiency. Greater than 87% of respondents clearly identified that osteoporosis, osteomalacia, and muscle or bone pain are chronic conditions that are highly associated with vitamin D deficient states. Conversely, respondents were less likely (20 to 50%) to associate vitamin D deficiency with individuals who have asthma, type 2 diabetes, and increased number or severity of infections. Other chronic diseases such as cancer, depression and autoimmune disease were identified as associated with vitamin D deficient states 56 to 68% of the time.

Nurse practitioners were then asked about their treatment preferences for vitamin D deficiency (see Table 7). Sixty-six percent of respondents stated that they would recommend an increase in intake of vitamin D rich foods as a part of their treatment plan. Respondents also recommended vitamin D supplementation a majority of the time; however, the dosage of supplement and frequency varied greatly with the very high dose 50,000 IU weekly dose recommended by 66% of NP respondents. Lastly, 75% of nurse practitioners stated that they would increase sun exposure as part of the treatment plan; however, sun exposure carries its own inherent risks.

Finally, participants were asked to identify which sources they were likely to use for new information on vitamin D. The data suggests that NPs obtain their information from a variety of sources including colleague discussion, physician and NP targeted journal articles, medical internet sites (non-journals) such as Web MD or the Mayo clinic, and medical conference presentations. NPs also responded that they sometimes or often use Wikipedia (51%) and non-medical magazines such as Ladies Home Journal or Good Housekeeping (27%) for medical information (see Table 8).

Discussion

Accurate knowledge regarding vitamin D deficiency is critical if NPs are going to make optimal patient care decisions related to vitamin D deficient states. Finding of this study show that NP knowledge of vitamin D and its deficient states is inconsistent. Even though NPs were able to identify some risk factors for vitamin D deficiency such as decreased sun exposure and obesity, other important risk factors such as darker skin color and breastfed infants were missed. NPs that are unaware of all of the major risk factors for vitamin D deficiency may not screen patient's appropriately not only leading to an unrecognized problem but also lack of treatment.

Even when patient risk is screened appropriately, many critical elements of vitamin D testing and treatment can be confusing. NPs need to be able to identify the appropriate lab test used for serum vitamin D assessment and the critical lab levels that indicate vitamin D deficiency states. When it comes to treatment NP knowledge is again inconsistent. Sixty-six percent of NP participants stated that they would increase food intake of vitamin D as part of their treatment plan; however, very few NPs were able to correctly identify the current RDA for vitamin D in either the adult or elderly population.

Most NPs were unable to correctly rank foods containing the most to least vitamin D which indicates that NPs may not know what foods are high in vitamin D. Additionally, even though it is important to incorporate vitamin D rich sources into a treatment plan, NPs also need to consider that only a few foods supply a noteworthy amount of vitamin D and that some of the best sources are fish. The importance of fish can be an issue in many parts of the country where fish is not fresh; therefore, not a part of the daily or even weekly diet. Incorporating fish in a diet is a special challenge for pregnant women because the same fatty fish that is high in vitamin D can also be high in mercury, limiting weekly intake. NPs need to have a better awareness of current recommendations and which sources of vitamin D are best in order to appropriately guide patients.

Additionally, even though most NPs state that they would provide some level of vitamin D supplementation as a part of their treatment plan, surprisingly 40% of respondents were unaware of the risk of vitamin D toxicity and death. Vitamin D is a fat soluble vitamin and although rare, cases of toxicity are reported annually usually in cases where serum vitamin D levels are greater than 200ng/mL (Lowe, Cusano, Binkley, Blaner, & Bilezikian, 2011; Maji, 2012). Furthermore, there was a wide range of supplementation strategies used by NPs in current practice with doses ranging from 400 to 2000IU daily to 50,000 IU per week. This suggests that there is marked variation in current vitamin D repletion strategies. Finally, 75% of nurse practitioners would recommend an increase in sun exposure as part of their treatment plan; however, use of sunscreen blocks the UVB rays that are essential to vitamin D production. Sun exposure without the use of sunblock would expose patients to the harmful effects of the UV rays. The American Academy of Dermatology recommends against the use of UV light

exposure as a treatment for vitamin D deficiency stating that the risks associated with exposure do not outweigh benefits especially when other forms of supplementation are available (2008).

In addition to inconsistent NP knowledge regarding vitamin D assessment and treatment, there is also a lack of awareness of the potential consequences and/or co-morbid conditions that are associated with low levels of vitamin D. Even though many NPs associate bone diseases such as bone pain, osteoporosis and osteomalacia with vitamin D deficiency, NPs were less aware that cancer, increased risk for severe infections, asthma, depression and autoimmune disease all have been associated with vitamin D deficiency. It is important that NPs are aware of the association between vitamin D deficiency and chronic disease. This knowledge can be used to screen additional patients who may not have traditional vitamin D risk factors and appropriate vitamin D repletion in those patients could augment traditional treatment strategies for their condition.

Finally, NPs are asked to make critical decisions regarding patient care and it is important that the NP obtains accurate information from credible sources. It is not surprising that most NPs turn to peer-reviewed medical journals for medical updates and information on vitamin D. Conference speakers and reliable colleagues can also be a resource for NPs. However NPs should be aware that medical websites, sites such as Wikipedia, and non-medical magazines are not optimal sources of information. Information in any of these sources may not be evidence based and can potentially increase confusion about medical topics. NPs should be reminded that evidence based

practice is the gold standard for treatment and that medical journals are the best source for peer- reviewed articles and information.

Limitations

Findings of the study are limited to a convenience sample of only 100 respondents. The sample was relatively homogenous with 80% of the respondents reporting their specialty as family nurse practitioner. The choice for respondent anonymity eliminated the ability for future follow up. Notwithstanding these limitations this study brings insight into the knowledge base of NPs regarding vitamin D deficient states and holds implications for education and practice.

Implications for Practice

Nurse practitioners should consider assessment for vitamin D deficiency in any patient with traditional risk factors or commonly associated co-morbid conditions. If nurse practitioners decide to treat vitamin D deficient states, they need to accumulate a knowledge base regarding risk factors, appropriate lab testing and evaluation, and treatment standards. Treatment plans should be based on thorough knowledge of the sources of vitamin D, vitamin D supplementation strategies and risks of treatment. NPs should carefully consider the risks of having patients increase sun exposure (without sunscreen) before recommending sun exposure as a treatment for low vitamin D. Diet alone is generally regarded as a poor source of vitamin D especially in individuals who will not eat fish and/or dairy products and even though increasing dietary intake can be a valid part of a treatment plan, changing diet alone may not be sufficient. NPs should also be aware of the recommendations created by the Endocrine Society for testing and treatment and use those recommendations as a guide to practice.

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Table 3 Demographics of the study sample (N=100)

Characteristic	N	%
NP Specialty Certification		
Family	70	70
Adult	17	17
Pediatric	1	1
Acute Care	4	4
Psychiatric	1	1
Dual Certification	5	5
Currently treating vitamin D deficiency		
Yes	80	80
No	20	20
Years Practicing		
<1year	7	7
2-5 years	23	23
6-10 years	28	28
11-15 years	13	13
16-20 years	9	9
21 – 25 years	2	2
>25 years	5	5

Table 4 Knowledge scores (range 0-6)

Total Score	N	%
0	8	8
1	24	24
2	22	22
3	25	25
4	18	18
5	3	3
6	0	0

Table 5 Knowledge score components

Component	N
Which laboratory test is used to determine Vitamin D levels?	
Correct	59
Incorrect	41
What is the serum lab value for vitamin D insufficiency?	
Correct	51
Incorrect	49
What is the serum lab value for vitamin D deficiency?	
Correct	41
Incorrect	59
Can vitamin D toxicity occur?	
Correct	61
Incorrect	39
What is the RDA of vitamin D for Adults ages 19 – 69yo?	
Correct	2
Incorrect	98
What is the RDA of vitamin D for elderly adults >70yo?	
Correct	16
Incorrect	84

Table 6 Knowledge score components eliminated from final Instrument

Question 1: A list of potential patients was given and participants were asked to mark (√) their perception of each patient's risk for having less than normal vitamin D levels. They could choose high risk, low risk or I don't know. Descriptions of the patients included:

(N=100)	%correct
55 year old Latino Male who works outside riding horses	6%
A Caucasian 3 month old who is exclusively breastfed	33%
An obese 39 year old African American female	86%
A Caucasian 9 year old girl with a normal BMI	78%
A 32 year old Caucasian female with a normal BMI that runs marathons	80%
A 22 year old Latina female who is underweight and works at a grocery store	91%
A 45 year old Caucasian female who is overweight and works a desk job	97%

Question 2: A list of specific risk factors and participants were asked to mark (√) their perception of each characteristic and its risk relationship for less than normal vitamin D levels.

(N=100)	% correct
Being underweight	17%
Relatively little time in the sun	95%
Beige skin with brown or olive tone- Mediterranean/Latino	38%
Obesity	74%
White –very fair skin with freckles	19%
Dietary intake high in fatty fish	73%
Dark Black skin	48%

Question 3: Participants were asked to rank in order from 1 to 7 the best sources of vitamin D (best=1) to the worst (worst=7) sources of vitamin D. The sources are listed below.

a. Fortified milk (1 cup)
b. Tuna, canned (3.6oz)
c. Egg yolk (1 egg)
d. Raw broccoli (1 cup)
e. Wild salmon(3.6 oz)
f. Exposure to sunlight (15 minutes)
g. Whole grain cereal (1 cup)

Question 4: Participants were given a list of chronic conditions and asked if those conditions are associated with vitamin D. The answer choices were yes, no, or maybe.

(N=100)	Yes	no	maybe	
Type 2 diabetes	50	13	37	
Osteomalcia/falls	94	2	4	
Increased risk of falls		72	11	17

Muscle/bone pain	87	1	12
Cancer	56	10	34
Asthma	19	43	38
Osteoporosis	94	0	6
Increased severity frequency of infections	50	11	39
Depression	68	8	24
Autoimmune disease	64	7	29

Table 7 Treatment preference for vitamin D deficiency

Treatment (N=100)	Consider	Not consider
Increase intake of vitamin D rich foods	66	31
Increase sun exposure	75	25
400-1000IU daily vitamin D supplementation	10	90
2000IU daily vitamin D supplementation	40	60
50,000IU weekly vitamin D supplementation	66	34

Table 8 Likely use of resources for information on vitamin D (N=100)

Source	Never	Sometimes	Very Often
Colleague discussion	20%	52%	28%
Conference Speaker	35%	47%	18%
Internet website other than journal (Web MD, Mayo)	15%	49%	36%
Medical (Physician targeted) journal articles	20%	45%	35%
Medical (NP targeted) journal articles	16%	41%	43%
Internet – Wikipedia	49%	35%	16%
Non medical magazine	73%	24%	3%

Conclusion to Final DNP Capstone Report

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Vitamin D deficiency is pervasive in the United States population and has now been associated with many acute and chronic conditions, especially bone disease and type 2 diabetes. Nurse practitioners are expected to make critical decisions regarding patient care and it is important that they have a good understanding of vitamin D deficiency ensuring that they can appropriately treat patients. The research in this capstone indicates that NPs have a significant knowledge deficit regarding the assessment and treatment of vitamin D deficiency. Optimal knowledge should include the definition of vitamin D insufficiency and deficiency and its correlation to chronic disease states, the risk factors and epidemiology of vitamin D deficiency, and the latest information on appropriate clinical screening and treatment of vitamin D deficiency as detailed in the second manuscript.

Even though vitamin D deficiency research is in a nascent stage, early research indicates that recognition and treatment could benefit patients. Through examining the current state of knowledge regarding vitamin D deficiency one can identify areas for education as well as future research potential. The potential of Vitamin D supplementation, which is easily accessible and inexpensive, to benefit public health is immense and worth the attention of both researchers and clinicians now and in the future.

Appendix A

The Nurse Practitioner and Vitamin D: Knowledge and Practices

Please indicate your answer to the following questions.

Demographic Information

1.Are you currently practicing in a nurse practitioner role?

_____ yes _____ no

2.Which of the following best describes your nurse practitioner specialty certification? (If you are certified in more than one specialty please mark all that apply).

_____ Adult Nurse Practitioner (ANP) _____ Neonatal Nurse Practitioner

_____ Family Nurse Practitioner (FNP) _____ Acute Care Nurse Practitioner

_____ Pediatric Nurse Practitioner (PNP) _____ Psych Nurse Practitioner

3. How many years have your been practicing as a nurse practitioner? _____

Knowledge Survey

1.Which of the following vitamin D substrates is the one most routinely used in serum laboratory testing of vitamin D?

_____ vitamin D hydroxylase

_____ 25-hydroxyvitamin D – 25(OH)D

_____ 1,25-dihydroxyvitamin D1,25(OH)

_____ previtamin D

_____ I don't know

2.At which of the following thresholds would you consider a patient to be insufficient of vitamin D?

_____ <60ng/mL

_____ <50ng/mL

_____ <40ng/mL

_____ < 30ng/mL

_____ <20ng/mL

_____ <10ng/mL

3. At which of the following thresholds would you consider a patient to be deficient of vitamin D?

_____ <60ng/mL

_____ <50ng/mL

_____ <40ng/mL

_____ < 30ng/mL

_____ <20ng/mL

_____ <10ng/mL

4. Is it possible for a patient to have a serum level of vitamin D that is toxic which can result in death?

_____ yes _____ no

5. The following is a list of potential patients. Please mark **(√)** your perception of each patient's risk for having **decreased** serum vitamin D levels.

Patient description	**High Risk for low vitamin D**	**Average Risk for low vitamin D**	**Low Risk for low vitamin D**	**I don't Know**
A 55 year old Latino Male who works outside riding horses	_____	_____	_____	_____
A Caucasian 3 month old who is exclusively breast fed	_____	_____	_____	_____
An obese 39 year old African American female	_____	_____	_____	_____
A Caucasian 9 year old girl with a normal body mass index	_____	_____	_____	_____
A 32 year old Caucasian female with a normal BMI who runs marathons	_____	_____	_____	_____

A 22 year old Latina female who is underweight and works at a grocery store	_____	_____	_____	_____
A 45 year old Caucasian female who is overweight and works a desk job	_____	_____	_____	_____

6.The following is a list of patient characteristics. Please mark **(√)** your perception of each characteristic and its relationship to risk of **decreased** serum vitamin D levels.

Characteristic	**High risk**	**Average risk**	**Low Risk**	**I don't Know**
Being Underweight	_____	_____	_____	_____
Relatively little time in the sun	_____	_____	_____	_____
Beige skin with brown or olive tone – Mediterranian/Latino	_____	_____	_____	_____
Obesity	_____	_____	_____	_____
White – very fair skin tone with freckles	_____	_____	_____	_____
Dietary intake high In fatty fish	_____	_____	_____	_____
Dark Black Skin	_____	_____	_____	_____

7.If you determine that your patient's vitamin D level is insufficient (mildly less than normal), which of the following are you most likely recommend? (Select all that apply).

_____ increase intake of foods that contain vitamin D

_____ increased indoor exercise

_____ Vitamin D supplementation of 400-1,000 IU daily

_____ Vitamin D supplementation of 2,000IU daily

_____ Vitamin D supplementation of 50,000IU per week

_____increase sun exposure

_____ I do not treat vitamin D insufficiency

_____ I do not currently test for vitamin D insufficiency

8. If you determine that your patient's vitamin D level is deficient (markedly less than normal), which of the following are you most likely recommend? (Select all that apply).

_____ increase intake of foods that contain vitamin D

_____ increased indoor exercise

_____ Vitamin D supplementation of 400-1,000 IU daily

_____ Vitamin D supplementation of 2,000IU daily

_____ Vitamin D supplementation of 50,000IU per week

_____increase sun exposure

_____ I do not treat vitamin D insufficiency

_____ I do not currently test for vitamin D insufficiency

9. The following is a list of foods/activities that contain vitamin D. Please rank in order from number 1 to number 7 the best sources of vitamin D. (Number 1 being the best source and Number 7 being the worst source).

fortified milk (1 cup) _____

Tuna, canned (3.6oz) _____

Egg yolk - 1 _____

Broccoli – 1 cup raw _____

Wild salmon (3.6oz) _____

Exposure to 15 min.
of sunlight _____

whole grain cereal –1 cup _____

10.What is the recommended daily allowance (RDA) of vitamin D (in international units = IU) set by the Food and Drug Administration for individuals 19 -69 years old.

_____ 400 IU

_____ 600 IU

_____ 800 IU

_____ 1200 IU

_____ 2000 IU

11. What is the recommended daily allowance (RDA) of vitamin D (in international units = IU) set by the Food and Drug Administration for individuals greater than 70 years old.

_____ 400 IU

_____ 600 IU

_____ 800 IU

_____ 1200 IU

_____ 2000 IU

12. Which of the following conditions/states so you believe to be associated with low serum levels of vitamin D? (Please select all that apply)

_____ type 2 diabetes

_____ increased risk of falls

_____ cancer

_____ osteoporosis

_____ depression

_____ osteomalacia/rickets

_____ muscle/bone pain

_____ asthma

_____ increased severity/ frequency of infections

_____ autoimmune diseases

_____ none of the above is associated with low vitamin D

13. The following is a list of resources which can be used to obtain clinical data regarding vitamin D. Please mark **(√)** the line that correctly indicates how often you have used each of the following resources in the last year for clinical information regarding vitamin D.

Resource	**Very Often**	**Sometimes**	**Not at all**
Discussion with Colleagues	_____	_____	_____
Conference Speaker	_____	_____	_____
Internet –Non Journal medical Site (Web MD; Mayo clinic)	_____	_____	_____
Medical Journal Articles (ie. New England Journal of Medicine; Lancet; Journal of the American Academy of Family Practice Physicians)	_____	_____	_____
Nurse Practitioner targeted medical journals (ie. Clinical Advisor; Journal of the American Academy of Nurse Practitioners).	_____	_____	_____
Internet - Wikipedia	_____	_____	_____
Non-Medical Magazine (Ladies Home Journal; Good Housekeeping)	_____	_____	_____

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