REPORT

Vitamin D supplementation in a nursing home population

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To determine if daily supplementation of 2000 IU of vitamin D_3 is able to normalize the 25(OH)D_3 status in a nursing home population, a group particularly prone to Vitamin D insufficiency. A chart review was performed to retrospectively determine the 25(OH)D_3 level in each nursing home patient ($N = 68$) who had received a minimum of 5 months of daily 2000 IU vitamin D_3 supplementation. 94.1% of nursing home residents had a 25(OH)D_3 level in excess of 80 nmol/L after a minimum of 5 months of daily 2,000 IU vitamin D_3 supplementation. No residents had 25(OH)D_3 levels in a toxic range. In order to improve health and well-being and to preclude preventable morbidity and mortality associated with 25(OH)D_3 insufficiency, all nursing home patients without contraindication should be routinely supplemented with (at minimum) 2000 IU of vitamin D_3 on a daily basis.

Keywords:
Geriatrics / Nursing homes / Seniors / Vitamin D

1 Introduction

With an aging population and more seniors living in continuing care facilities than ever before, there is increasing attention to the health requirements of the elderly within our communities – a group which consumes a disproportionate share of health care resources. Juxtaposed with this demographic is emerging evidence that many individuals, including seniors, are deficient in vitamin D[1–3]–a hormone involved in genetic regulation and a molecule involved in assorted physiological processes. As recent evidence confirms that sufficiency of vitamin D is associated with greatly diminished morbidity and mortality, [2, 4–8] it is necessary to secure adequate levels in the subpopulation of institutionalized seniors, a subgroup particularly predisposed to vitamin D insufficiency. By doing so, there is potential for improved individual health and well-being, as well as the preservation of health care resources that might otherwise be devoted to dealing with preventable conditions in the institutionalized elderly.

1.1 Biological role of Vitamin D

Vitamin D functions as a biological hormone and has myriad functions within the human body. In response to ultraviolet-B radiation from sunlight, vitamin D is obtained primarily from conversion of cutaneous 7-dehydrocholesterol to cholecalciferol (vitamin D_3), but can also be acquired from a limited number of primary foods, fortified foodstuffs, and through supplementation [1]. Vitamin D_3 is hydroxylated in the liver to 25(OH)D_3 – the main circulating metabolite which is used as the predominant biomarker of clinical vitamin D status. 25(OH)D_3 is also the substrate used by the kidney for conversion to 1,25$(OH)_2D_3$ – the hormonally active form of vitamin D which is used for myriad functions including calcium homeostasis. Some cells may have the ability to locally convert 25(OH)D_3 to 1,25$(OH)_2D_3$ via the 1α-hydroxylase enzyme in an autocrine manner, allowing for the widespread vitamin D impact on cellular functions [5–6]. More than 30 tissues are known to have nuclear receptors for this molecule, which accounts for the important role of 1,25$(OH)_2D_3$ in assorted physiological processes.

At a molecular level, vitamin D acts as a lever to initiate genetic transcription in over 900 genes as determined by microarray and silico analyses [9] – as a result, many vitamin D deficient seniors living in nursing homes are unable to carry out normal physiological functions in their body. At a macroscopic level, insufficient levels of vitamin D have been repeatedly associated with myriad health afflictions including cancer, autoimmune disease, diabetes, neurological problems, respiratory illness and so on [2, 8]. Normalization of vitamin D status in seniors residing in nursing homes has the potential to diminish morbidity and mortality, and to significantly improve well-being and quality of life.

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1.2 Vitamin D status in institutionalized seniors

Many factors contribute to the high risk of vitamin D inadequacy in nursing home populations. As cutaneous production derived from sunlight, rather than dietary ingestion, is the chief source of vitamin D, [10] seniors in institutions which provide both residential accommodation and health care, often have limited access to direct sunlight because of mobility issues. Furthermore, vitamin D production diminishes with age, another factor leading to deficiency in the elderly. Finally, populations living at high latitudes, where ultraviolet-B sunlight intensity is too weak for extended periods to induce sufficient vitamin D skin synthesis for many people [11], are at pronounced propensity to experience vitamin D insufficiency.

Previous work has confirmed that elderly residents in care facilities generally do not achieve a minimum recommended intake of vitamin D_3 (which for this age group is 600 IU of vitamin D) [12] from diet alone. One Canadian study of 22 nursing home patients with an average intake of 467 IU of vitamin D had a mean 25(OH)D level of 40 nmol/L [13]. With a mean $25(OH)D_3$ level of 39.9 nmol/L in the winter and 44.9 nmol/L in the summer, another study of elderly patients in long-term care facilities found that 18% of patients had severe vitamin D deficiency (defined as <25 nmol/L of $25(OH)D_3$) in some seasons (usually late winter and spring) but at least 9% remained severely deficient even in summer [14]. Another recent study demonstrated severe vitamin D deficiency in many nursing home residents with a mean $25(OH)D_3$ value of 19.0 nmol/L even in the summer compared to non-institutionalized seniors dwelling in the community who were found to have a mean $25(OH)D_3$ level of 67.6nmol/L [3]. Furthermore, the risk of community dwelling seniors needing admission to a long-term nursing home facility is significantly increased with low vitamin D status [15]. The risk of entering a nursing home with levels of 25(OH)D <75 nmol/L is 1.92 greater than if levels are >75 nmol/L. With levels of 25(OH)D <25 nmol/L, the relative risk increases to 3.48.

Supplementation of vitamin D in one nursing home population resulted in an increase of 4.7 nmol/L for every 100 IU of vitamin D_3 given [16]. Another residential care study using 100 000 IU of oral vitamin D_3 every 3 months resulted in a mean 25(OH)D level of 86.4 nmol/L prior to the third dose, with levels as low as 60 nmol/L [17]. In this study, the mean level taken one week after the third dose increased to 114.1 nmol/L, with significant changes in both peak and trough levels amongst the patients studied. The mean 25(OH)D level of residents prior to supplementation was 36.4 nmol/L–once again demonstrating a 4.5 nmol/L increase for every 100 IU of vitamin D_3 given [17].

Accordingly, this current study was undertaken to assess the impact of routine vitamin D_3 supplementation on a group of seniors residing in a nursing home. The objective was to see if a clinical decision to provide supplemental intake to institutionalized seniors normalized the vitamin D status in most residents and to reasonably ascertain if routine vitamin D_3 supplementation may be a worthwhile public health measure in institutions for seniors' care–a locale where residents are at high risk for vitamin D insufficiency.

2 Study parameters

In response to extensive evidence in the medical literature regarding the benefits of sufficient vitamin D [1, 8], a decision had previously been made that all existing and new residents in a nursing home facility (excluding those with known contraindications such as hypercalcemia, sarcoidosis, or malignancy with bone involvement) would receive daily supplementation with 2000 IU vitamin D_3 as part of their health care program. This level of supplementation was chosen based on the outcome of various studies in the literature [2, 16–17], and also because the 1997 upper tolerable level of daily vitamin D intake with no known side effects was documented at 2000 IU of vitamin D_3 per Institute of Medicine. Previously, supplementation intake levels in the nursing home institution were about 400 IU per day for these residents–an intake level which has been shown to not reduce falls in the elderly [4]. No patient had preexisting contraindications for vitamin D supplementation.

Clinical improvement was noted in many patients and $25(OH)D_3$ levels were collected and monitored after supplementation was instituted. Application was subsequently made to the Health Research Ethics Board at the University of Alberta to perform a retrospective chart review of the clinical and laboratory data associated with supplementation of 2000 IU of vitamin D_3 in these nursing home patients and approval was received on February of 2009.

This study involved a retrospective chart review on 68 patients in the nursing home setting who had received Vitamin D_3 2000 IU daily for a minimum of 5 months (range 5 to 10 months with most patients having supplementation for 8 months). All 74 eligible nursing home patients in one clinician's practice were included except one patient who refused to take any medications or vitamins at all, and 5 patients who were inadvertently given only 1000 IU daily of vitamin D_3 rather than the prescribed 2000 IUs. Compliance according to nurses and pharmacists administrating the daily vitamin D_3 was near 100%. The study was undertaken in Edmonton 53°N, Alberta, Canada, a locale at high latitude where mean vitamin D levels in the population-at-large are insufficient for optimal health [2].

In this study, only blood levels for $25(OH)D_3$ drawn 5 months or longer after supplementation was initiated were used - recognizing that the half-life of vitamin D is about 3–4 weeks and steady state is achieved 3 to 4 months after supplementation is commenced [18]. Vitamin D status was determined by measuring $25(OH)D_3$ levels using Liquid Chromatography tandem Mass Spectrometry (LC-MS/MS). The inter confidence intervals for the assay are −6% at 150 nmol/L, 7% at 27 nmol/L and 8% at 13 nmol/L with the

lowest level of detection of 2 nmol/L from our local lab. No patient identifiers were recorded other than age, gender, and length of time on vitamin D_3 supplementation. Calcium and albumin levels were determined at the same time as the 25(OH)D_3 assessment and recorded in order to rule out associated hypercalcemia in any patients. Only one patient in the residences had a level done prior to supplementation with a 25(OH)D level of 35 nmol/L which is approximately consistent with all the reports in the literature as outlined above [13–17].

3 Results

The average age of the patients was 80.7 years (range: 58 to 100 years of age) with a standard deviation of 9.8 years. Of the 68 patients, 19 were male and 49 were female. After a minimum of 5 months of vitamin D supplementation, the mean 25(OH)D levels in these patients was 119.4 nmol/L with standard deviation of 28.1 nmol/L. The range of 25(OH)D_3 levels was 61 nmol/L to 184 nmol/L. All patients had levels well below toxicity, a phenomenon which does not generally occur with 25(OH)D_3 levels under 220 nmol/L [19]. 64 patients (94.1%) reached a 25(OH)D_3 level exceeding >80nmol/L, a level often used in the literature as indicative of vitamin D adequacy. (Table 1) In this study, the rise in 25(OH)D level was about 4–4.2 nmol/L for every 100 units of vitamin D given - based on an initial 25(OH)D level of 35–40 nmol/L as is typically found in several studies of this population demographic.

Only 4 of the 68 patients receiving supplementation did not achieve levels >80nmol/L. Of these 4 patients, one had a BMI in the obese range, one had darker skin, and remaining 2 had no identifiable risk factors. None of these 4 patients were taking corticosteroids - which can result in low 25(OH)D levels even after supplementation. Hypercalcemia was not found in any of the 64 patients.

4 Discussion

In this study, repletion with 2000 IU of vitamin D_3 resulted in 94% of patients achieving the desired vitamin D status; 6% did not achieve the preferred objective. Compared to other studies on vitamin D supplementation, compliance was consistently achieved in this instance, an occurrence which is not always realized [20]. There was no evidence of hypercalcemia in any of the patients and none had levels that potentially cause toxicity symptoms. In other words, vitamin D_3 supplementation at 2000 IU daily appears to be a safe and tolerable dose that is unlikely to be associated with any toxicity. In fact, toxicity has not been noted using 2000 IU a day in several studies and recently a review has shown that the upper limit of safe tolerability may be a dose as high as 10 000 IU a day [19]. Generally it is accepted that the rise in 25(OH)D is about 2.5 nmol/L for every 100IU of vitamin D_3. The relatively large increase in the 25(OH)D level of 4–4.7 for every 100 IU of vitamin D_3 in this study and studies listed above may simply be a reflection of the marked deficiency often found in this population group [21]. It appears that the rate of rise in 25(OH)D with vitamin D supplementation may be more pronounced with very low pre-existing levels.

Vitamin D is inexpensive and easily administered either by pill or drops. In this study, the cost of this vitamin D_3 intervention was calculated to be $12.60 per year, not including employee costs associated with packaging and distribution of the tablets by staff.

A preferred method for assessing and managing vitamin D related health concerns rather than routine supplementation is the determination of individual serum 25(OH)D_3 levels and supplementation with specific vitamin D_3 dosages in order to achieve a targeted vitamin D status [2]. With need for i) increased understanding of vitamin D and nutrition research in general by clinicians [22], ii) routine 25(OH)D laboratory testing [2], iii) individualized dosing, and iv) enhanced training for health professionals dealing with seniors, it may take time before adequate knowledge translation is completed whereby preferred vitamin D management protocols are widely implemented in clinical practice [2]. In the interim, however, an inexpensive and easy to implement strategy to provide routine supplementation for nursing home residents may immediately improve quality of life for many seniors.

Table 1. Parameters of patients in this study

Parameters	Number, Mean and Standard deviation (SD)	
Gender $N = 68$	19 Male and 49 Female	
	Range	Mean
Age	58–100	80.7 $\pm$ 9.8 (SD)
25(OH)D level in nmol/L (after 5 or more months of oral supplementation of vitamin D_3 at 2000 IU/day)	61–184	119.4 $\pm$ 28.1(SD)
Time of supplementation	January to October with the majority of patients receiving more than 8 months of supplementation	

As well as the potential for multisystem benefit by achieving vitamin D adequacy, studies in the elderly have shown that vitamin D_3 supplementation generally improves muscle mass, reduces upper body sway, improves balance and significantly decreases the incidence of falls [23]. In fact, supplemental vitamin D_3 doses >800 IU have been demonstrated to reduce falling events by 72% [4]. Accordingly, it is evident that interventions to achieve optimal $25(OH)D_3$ status in institutionalized seniors have the potential to ameliorate quality of life significantly. As nursing home seniors have high rates of illness and consume a major portion of health care dollars, the findings of this study concur with those of other advocates for vitamin D supplementation who suggest that the present guideline of 600 IU/day is woefully inadequate for this group of patients [24]. Finally a recent review paper has suggested that the economic savings for individual countries and public health care systems such as in Canada can be quite substantial simply by normalizing vitamin D status in the general population, including the institutionalized elderly [25].

Although the sample size of this work is relatively small, the results are very suggestive that significant benefit can potentially be achieved, but the findings of this study behoove further research. A well-designed prospective study with a larger sample size, and which includes testing for various markers including pre and post: parathyroid hormone levels, 25(OH)D levels, insulin levels, and hip/flexor muscle strength, as well as documentation of BMI, glucocorticoid use and other confounders may add considerably to existing knowledge on the need for routine vitamin D supplementation in this important group within the population.

5 Conclusion

Fractures, ongoing musculoskeletal pain, diabetes, respiratory infections, cancer, congestive heart failure and myriad chronic diseases in the elderly are commonly associated with vitamin D deficiency. In turn, vitamin D deficiency as reflected by suboptimal $25(OH)D_3$ levels is widespread among elderly institutionalized patients as a result of limited sun exposure, advancing age, and inadequate vitamin D_3 intake. This is the first study reported in the literature (to the authors' knowledge) of daily supplemental vitamin D_3 dose requirements to achieve $25(OH)D_3$ values of >80 nmol/L in most nursing home residents. This report demonstrates that daily supplementation with 2000 IU of vitamin D_3 can achieve 25(OH)D levels of >80 nmol/L in most residents living in a nursing home setting, with no levels reaching a toxic range - thus confirming the utility of oral vitamin D supplementation to improve vitamin D status [16].

The authors have declared no conflict of interest.

6 References

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