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Vitamin D and Fall Prevention in Long Term Care

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Abstract

The purpose of this literature review was to look at the use of vitamin D supplementation in fall prevention among older adults in long term care. Databases searched included CINAHL, MEDLINE, and PubMed as well as hand-searched bibliographies of selected articles. Keywords used included vitamin D, ergocalciferol, cholecalicferol, falls, accidental falls, nursing home, and long term care. Results were narrowed down through use of randomized control trials, dates through the year 2003, use of English language, and elimination of studies which included community-dwelling elders. A variety of research articles were found, those included in the review consisted of four randomized control trials and one cohort study. Analysis and synthesis of the articles found led to moderately strong results favoring use of vitamin D in fall prevention.

It is estimated that 50% of institutionalized adults will fall in any given year. In the older adult falls may result in disability, functional decline, reduced quality of life, fear of falling or even death (Ham, Sloane, Warshaw, Bernard, Flaherty, 2007). In fact, among older adults falls are the leading cause of accidental death with nursing home residents making up 20% of those deaths (Center for Disease Control [CDC], 2012b). In 2010, the estimated medical costs of treating fall related injuries equaled $30 million (CDC, 2012a). This number is only expected to rise as society ages. Given the currently estimated 1.5 million older adults residing in long term care it is integral to discover how to effectively decrease the prevalence of falls (CDC, 2012b). Knowing this it is important to ask: in institutionalized adults aged 65 or greater does the use of vitamin D supplementation reduce fall risk compared with those not receiving vitamin D?

Vitamin D is a fat soluble vitamin that exists in two different forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). The major difference between the two is a longer half-life in vitamin D3 allowing for less frequent dosing (Kennell, Drake & Hurley, 2010). When initially absorbed, vitamin D is biologically inert and must go through two hydroxylations to become active. The first conversion occurs in the liver and the second occurs in the kidneys. It is known that vitamin D promotes calcium absorption in the gut and is involved in cell growth, neuromuscular and immune function, and reduces inflammation (Office of Dietary Supplements, 2011).

Older adults as a whole are at greater risk for vitamin D deficiency. According to Kennel et al. (2010), 25-50% of nursing home residents are vitamin D deficient. This is due to the decreased ability to synthesize vitamin D through the skin, less time spent outdoors and decreased oral intake of the vitamin (Office of Dietary Supplements, 2011). Even when exposed to similar amounts of daylight, older adults produced only 25% of cutaneous vitamin D compared to young adults. This deficit may be magnified by living northern climates. In 2008, Minnesota had less than 50% of days with enough ultraviolet light to affect vitamin D synthesis (Kennel et al., 2010).

Toxicity is a concern when one is receiving a vitamin from multiple different sources such as vitamin D. Although extremely rare, vitamin D toxicity may occur when taking doses greater than 10,000 International Units (IU) per day for a prolonged period or with high levels of calcium intake. Symptoms of hypervitaminosis D include constipation, nausea, dehydration, anorexia, fatigue, and arrhythmias (Office of Dietary Supplements, 2011; U.S. National Library of Medicine, 2012). Symptoms that are more serious include effects of hypercalcemia such as vascular calcification which may cause damage to the heart, blood vessels and kidneys (Office of Dietary Supplements, 2011).

Literature Review

The literature review included on-line database searches, current guidelines by the American Geriatrics Society and the United States Preventative Service Taskforce, and hand-searched bibliographies of selected articles.   Databases searched included CINAHL, MEDLINE, and PubMed. Keywords used included vitamin D, ergocalciferol, cholecalicferol, falls, accidental falls, nursing home, and long term care. Results were narrowed down through use of randomized control trials, dates through the year 2003, use of English language, and elimination of studies which included community-dwelling elders. After reviewing 45 articles that met the inclusion and exclusion criteria, four randomized control trials were found that addressed the question and all others were cohort or retrospective studies.

Analysis

Only a few studies exist that address the question: in institutionalized adults aged 65 or greater does the use of vitamin d supplementation reduce fall risk compared with those not receiving vitamin D? The John Hopkins Nursing Evidence Based Practice (JHNEBP) scale was used to categorize the articles found based on strength and quality of evidence. Using these criteria four level one randomized control trials were found, along with one level three prospective cohort study (Newhouse, Dearholt, Poe, Pugh, & White, 2007).

Study I

Flicker et al (2005) examined whether vitamin D supplementation can reduce the incidence of falls and fractures in older people in residential care who are not classically vitamin D deficient. This was a randomized, placebo-controlled, double-blinded experimental study performed over a two year period. Falls were defined as "an event that results in a person coming to rest inadvertently on the ground or other lower level" (Flicker et al, 2005, p. 1883). Participants included 628 subjects, 95% of whom were women with a mean age of 83.4 residing in 60 assisted living facilities and 89 nursing homes across Australia. Exclusion criteria were, medication and conditions affecting bone and mineral metabolism, use of vitamin D in the past three months, and vitamin D level less than 25 nmol/L as below this was level was deemed unethical not to treat. Subjects were randomized into a control group and intervention group via computer generated lists. Each group had similar baseline characteristics included cognitive status and walking ability. The intervention group initially received vitamin D2 10,000 IU once weekly. The dose was switched at an unknown time to 1,000 IU daily when the previous dose was taken off the market. The control group received a placebo identical in shape and size as the supplement. Both groups received 600mg of calcium carbonate daily. Falls were recorded via monthly diaries kept by residential care staff (Flicker et al., 2005).

Statistical analysis was performed using logistic regression, Cox proportional hazard and negative binomial models. When the vitamin D supplement group was compared to the control group an incidence rate ratio of 0.73 (95% confidence interval (CI) = 0.57-0.99) was seen. When subjects were eliminated based on less than 50% compliance, the incidence rate ratio was reduced to 0.63 (95% CI=0.48-0.82). In terms of time to first fall, the hazards ratio was 0.86 (95% CI= 0.70-1.06). This did not reach statistical significance. The number needed to treat analyses was based off of absolute risk differences in the treatment group falls compared to control group falls. It suggested that 12 people needed to be treated to prevent one fall during a two year period (Flicker et al., 2005).

Using the JHNEBP scale, this study's strength of evidence was a level one as it was a randomized experimental study (Newhouse et al., 2007). Limitations of the study included use of a population that is considered high risk and the change in results may be due to regression to the mean versus an actual improvement because of the intervention. This is a common issue affecting internal validity when extreme results are used in analysis. The study saw a large dropout rate related to death and illness which is uncontrollable given the population age and length of study. Generalizability is limited due to majority of subjects being female and location of study. The study took place in Australia which has different climate and sun exposure than other countries potentially affecting vitamin D levels (Flicker et al. 2005). Given the strong design, large sample size, and definitive conclusions that are consistent with current research this study had an A rating for quality (Newhouse et al., 2007).

Study II

Broe et al. (2007) examined the effect of four different vitamin D doses on fall risk in elderly nursing home residents. This study was a secondary data analysis of a previously conducted five month, randomized, double-blind, placebo-controlled trial that tested different doses of vitamin D against placebo on vitamin D status. The secondary analysis involved creation of a falls dataset in which participants identification number was linked with reported falls during the study period. In this study, falls were described as “a sudden, unintentional change in position causing a resident to fall on the ground” (Broe et al., 2007, p. 235). Participants included 124 nursing home residents from one long-term care facility in Boston, Massachusetts. Inclusion criteria included a six month life expectancy, ability to swallow, and three month residency at the facility. Exclusion criteria included specific medical conditions and medication use, severe mobility limitations, and recent fracture. Majority of the participants were female, average age was 89, 63% were taking a daily multivitamin, and 54% had serum vitamin D levels less than 20. Subjects were randomly assigned to one of five groups and given either a placebo or vitamin D2 in one of four strengths (200 IU, 400 IU, 600 IU, and 800 IU). Fall information was gathered through the facilities incident reporting system in which all falls are to be documented by care staff (Broe et al., 2007).

Statistical analysis was performed using multiple models. The Cox proportional hazard model found a reduction in risk in the 800 IU with a hazards ratio 0.44 (95% CI = 0.15-1.28). When this was compared to the combination of all other groups a 71% lower risk was found with an adjusted hazards ratio of 0.29 (95% CI = 0.11-0.72). However, no statistical significant difference was found between any of the intervention groups or placebo in terms of time to first fall. The Poisson regression model found an incidence rate ratio of falls was only significant in the 800 IU group, 0.28 (95% CI = 0.10-0.75) when adjusted for age and multivitamin use. These findings are similar to other studies which found that vitamin D supplements decreased the incidence of falls but only in doses greater or equal to 800 IU daily. This correlated to the serum vitamin D levels found at the end of the study. The 800 IU group had a mean serum vitamin D level of 29.95, compared to other groups which had averages ranging from 22-24 (Broe et al., 2007).

Using the JHNEBP scale, this study's strength of evidence was a level one as it was a randomized experimental study (Newhouse et al., 2007). However, the retrospective secondary analysis does decrease internal validity as number of falls may have been under reported. Researchers felt results of study were still valid as this limitation equally affected all groups. Other limitations of the study included concomitant use of multivitamin containing vitamin D among some study participants. Generalizability is a factor given a smaller sample size of mostly Caucasian females, multivitamin use and overall better health than other residents in the facility (Broe et al., 2007). This study has a B rating for quality given the strong original design of the primary study, further analysis of serum vitamin D levels to compensate for multivitamin use, and definitive conclusions that are consistent with a large literature review of current research (Newhouse et al., 2007).

Study III

Flicker et al. (2003) performed a prospective cohort study that examined low serum vitamin D as an independent factor for falls in long term care. Falls were recorded in fall diaries by staff and defined as “an event that results in a person coming to rest inadvertently on the ground or other lower level” (Flicker et al., 2003, p. 1535). Participants included 627 women residing in 60 assisted living facilities and 89 nursing homes across Australia. They were divided into cohorts based on their living environment, assisted living versus nursing home. Baseline characteristics analyzed among the cohorts included age, weight, cognitive status, walking ability, and outdoor exposure. Analysis of baseline characteristics found subjects in the nursing home had increased cognitive impairment, were less active and had less outside exposure when compared to those in assisted living. At the beginning of the study, serum vitamin D was drawn and falls were then recorded in diaries for an average of 145 days in assisted living and 168 days in nursing homes. At the end of the collection period, fall rates were compared between the assisted living and nursing home residents. A separate comparison was made between the bed bound and non-bed bound residents (2003).

The Cox proportional hazards model was used to look at the correlation between vitamin D level and rate of falls. Results showed that 97% of all subjects were vitamin D deficient, defined as less than 25 nmol/L. As a univariate fall risk factor, low serum vitamin D levels had a hazards ratio of 0.77 (95% CI = 0.62-0.94). After adjusting for known risk factors including cognitive impairment and medications, elevated serum vitamin D remained independently associated with lower risk of falls (hazards ratio of 0.74; 95% CI = 0.59-0.94). This association was only found among assisted living residents not among the nursing home residents. This information helped support the idea that elders often have deficient levels of serum vitamin D, which may contribute to the incidence of falls despite known risk factors in long term care (Flicker et al., 2003).

Using the JHNEBP scale, this study's strength of evidence was a level three as it was a prospective cohort study and has a B rating for quality (Newhouse et al., 2007). Given the design and lack of intervention, the evidence cannot support a cause and effect relationship between vitamin D supplementation and fall prevention.   However, findings do support an association between higher vitamin D levels and fewer falls that is consistent with other research results. Generalizability may be affected by use of strictly women in Australia where climate differs from other countries (Flicker et al., 2003).

Study IV

Law, Withers and Morris performed an experimental study which examined vitamin D supplementation and the risk reduction of fracture or falls in older adults living in long term care over a 10 month period. In this study, what constituted a fall was not explicitly described. Participants included 3,717 elders from 118 different nursing homes throughout Britain. The average age was 85, 76% were female, and resided in assisted living, skilled care, or memory units. Most of the facilities were comprised of one or more identical but separate 30 bed units. Each individual unit was treated as a randomization unit. The treatment groups received 2.5 mg of vitamin D2 every three months which is the equivalent of 1,100 IU daily. The control groups were not given a placebo. Staff at the facilities recorded falls in a fall diary per their normal protocol. They were not aware that fall occurrence was the measured outcome in the study (2006).

Result analysis was performed using a Poisson regression model which took into account the resident's age, gender, length of time in the trial, and cluster randomization. The relative risk of having at least one fall when comparing the treatment group to the control was 1.09 (95% CI = 0.95-1.25). Given the results, this study does not show any benefit with vitamin D and the fall reduction (Law et al, 2006).

Using the JHNEBP scale, this study's strength of evidence was a level one as it was a randomized experimental study (Newhouse et al., 2007). Limitations of the study included a large number of participants unable to complete the study due to death, moving, or addition of vitamin D by their primary care provider (Law et al., 2006). Randomization of subjects by unit rather than on an individual basis decreased the internal validity of the study as factors such as staff, unit layout, and fall prevention may differ. Lack of placebo and non-research staff administering the treatment also may have had effect on the results seen. Given the limitations, the quality of evidence was a level B (Newhouse et al., 2007). Generalizability of the results may be limited as subjects in the study were found to have overall lower incidence of falls, and higher initial serum vitamin D levels than other institutionalized adults (Law et al., 2006).

Study V

Bischoff et al. performed an experimental study, which examined the effects of vitamin D plus calcium on muscle strength and reduction of fall risk over a three month period. Falls were defined as "unintentionally coming to rest on the ground, floor or other lower level" (Bischoff et al. 2003, p. 344). Participants included 122 women with an average age of 85.3 residing in long term care in Switzerland. Inclusion criteria were age greater than 60 and an ability to walk about 10 feet without use of any aids. Exclusion criteria included certain medical conditions, history of fracture or stroke within the past three months, and use of osteoporosis treatment in the past year. The study was performed during the winter months to elicit the greatest difference in serum vitamin D levels between the intervention and control groups. After a six week pretreatment period in which strictly the number of falls were looked at, subjects were randomized by an independent statistician. Those in the treatment group received two tablets containing 400 IU cholecalciferol plus 600mg calcium carbonate. The control group received two tablets containing only 600mg calcium carbonate. Patients, care staff, and researchers were all blinded to group allocation. Falls were recorded by nurses per fall protocol when a fall either was observed or reported (2003).

Statistical analysis included the Poisson regression model to compare the number of falls between the groups. The regression model adjusted for many variables including number of falls in pretreatment period, age, height, weight, body mass index, use of walking aide, previous vitamin D use, Charlson Comorbidity index, number of medications at baseline, length of residency at study start, length of time in study, muscle strength and function, baseline serum vitamin D level, and serum albumin. After the adjustment, vitamin D plus calcium accounted for a 49% reduction in falls per person. The study also found other strong predictors of falls including history and frequency of falls and age. The actual number of fallers was not statistically different between the two groups suggesting that vitamin D does not necessarily prevent a first fall rather reduces recurrent falls (Bischoff et al, 2003).

Using the JHNEBP scale, this study's strength of evidence was a level one as it was a randomized experimental study (Newhouse et al, 2007). Limitations of the study included dropout rate which was expected and care was taken to design the study to minimize effects. The issue of multiple falls per person was also a factor that could affect results. To account for this, researchers controlled for the number of fallers and falls in the pretreatment period and adjusted for this in the regression analysis (Bischoff et al., 2003). Given the study design, double-blinding, and methods put into place to correct for limitations, the quality of evidence was a level A (Newhouse et al., 2007). Generalizability may be affected by use of strictly Caucasian women within a country that does not require vitamin D fortification (Bischoff et al., 2003).

Synthesis

After an extensive literature review and analysis of the five studies, one can conclude that vitamin D supplementation does provide some protection against falls. The majority of the studies analyzed showed a reduction in the incidence of falls when vitamin D was given (Bischoff et al., 2003; Broe et al., 2007; Flicker et al., 2003; Flicker et al., 2005). Only one study did not detect any change in fall frequency (Law et al., 2006). While a reduction in number of falls was seen with vitamin D, a reduction in the total number of persons with falls was not seen (Bischoff et al., 2003; Broe et al., 2007; Flicker et al., 2003; Flicker at al., 2005).

Recommendations

Fall prevention is a priority when providing care for the older adult in long term care. Falls are of great concern in this high risk population as they result in many injuries and are the leading cause of accidental death (CDC, 2012b; Ham et al., 2007). Multiple modalities have been used to prevent falls including exercise, use of walking aids, minimizing medications, and timed toileting (Ham et al., 2007). Seldom is vitamin D use seen in clinical practice despite the supporting evidence.

Based off the articles researched, it should be recommended that institutionalized older adults receive a daily dose of at least 800 IU of vitamin D daily to help prevent falls. This modality should not be used alone as findings suggest that vitamin D may not prolong the time to first fall but rather will reduce the number of total falls (Broe et al., 2007; Bischoff et al., 2003; Flicker et al., 2003; Flicker et al., 2005). Therefore, it is important to continue use of multiple strategies to prevent falls along with vitamin D supplementation.

The risks of vitamin D supplementation are very low. Toxicity is a rare occurrence and typically occurs when taking doses greater than 10,000 IU per day for a prolonged period (Kennel et al., 2010). Symptoms of vitamin D toxicity are relatively mild and include constipation, nausea, and dehydration (Office of Dietary Supplements, 2011). More concerning are high levels of calcium which can cause damage to the heart and kidneys (U.S. National Library of Medicine, 2012). Before starting a patient on vitamin D, it is important to evaluate their past medical history, vitamin D level and calcium level.

Further research is needed in prevention of falls with vitamin D supplementation. First area that needs further research is dose of vitamin D that best prevents falls. The five studies analyzed used different doses of vitamin D and only one compared different doses to each other. To provide the best recommendation it is important to know the most beneficial dose without risk of harm. The second area that needs further research is dosing schedule. The majority of these studies provided daily dosing but one gave monthly dosing. In clinical practice, dosing may vary from daily to yearly and it is important to discover the best delivery schedule to prevent falls. Another area of further research needed is that of vitamin D2 versus vitamin D3 supplementation. Four of the five studies used vitamin D2 in their research but in the United States, vitamin D3 is often used. This may have an impact on serum vitamin D levels and ultimately fall prevention as half-lives differ between the types of vitamin D given (Kennel et al., 2010). Lastly, the role of calcium plus Vitamin D could be explored. Two of the five studies included calcium supplements and saw a reduction in falls. It is important to investigate if calcium provides an agonistic affect for fall prevention, or if it increases toxicity risks.

Fall prevention among older adults in long term care is of great importance to maintain quality of life and prevent accidental injury or death. Falls are a complex problem that requires multiple modalities to prevent including use of vitamin D. Based on research, a daily dose of 800 IU vitamin D3 is recommended to prevent falls unless contraindicated. Further research is still needed to provide optimum dose, dosing schedule, and form of vitamin D that best prevents falls.

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