✠ **LITERATURE REVIEW** ✠

Veganism and osteoporosis: A review of the current literature

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Veganism and osteoporosis: A review of the current literature

The purpose of this review is to examine the current literature regarding calcium and Vitamin D deficiencies in vegan diets and the possible relationship to low bone mineral density and incidence for fracture. Prominent databases were searched for original research publications providing data capable of answering these questions: (i) Do vegans have lower-than-recommended levels of calcium/Vitamin D? (ii) Do vegans have lower bone mineral density than their non-vegan counterparts? (iii) Are vegans at a greater risk for fractures than non-vegans? The findings gathered consistently support the hypothesis that vegans do have lower bone mineral density than their non-vegan counterparts. However, the evidence regarding calcium, Vitamin D and fracture incidence is inconclusive. More research is needed to definitively answer these questions and to address the effects of such deficiencies on the medical and socioeconomic aspects of life.

Key words: bone mineral density, calcium, osteoporosis, vegan diet, vitamin deficiency.

INTRODUCTION

Choosing a vegan lifestyle—in which one eats plant products only and 'uses no products derived from animals, as fur or leather'[1]—is done for a variety of reasons. Some of those reasons include better health, the protection of animals and the environment,[2] the preference of vegetables to meat and social influences.[3] Nutritionists and researchers have expressed concerns over the possibility that individuals choosing to follow such restrictive diets might experience vitamin and/or mineral deficiencies.[4] This concern is even more poignant when one considers the fact that the nutritional content of human food products has declined since the 1930s.[5] The mineral and vitamin deficiencies that come to the forefront when examining possible problems with a vegan diet are those related to calcium and Vitamin D.

Calcium and Vitamin D, although two separate nutrients, need to be examined in tandem because of the human body's need for Vitamin D to properly utilize calcium, specifically Vitamin D3. In most cases, the body receives its supply of Vitamin D3 from two chief sources—animal products and *in vivo* synthesis via exposure to natural light.[6] Restriction of animal product consumption removes the ability of an individual to orally ingest Vitamin D3, leaving the biosynthesis that takes places during exposure to direct sunlight as the body's primary source of Vitamin D3. This creates a significant problem for vegans who live in areas of the world where the number of hours in which they can absorb UVB (ultraviolet B—the band of the ultraviolet spectum responsible for the synthesis of Vitamin D3) rays from direct sunlight is limited. It is also an issue for vegans who are dark-skinned or elderly, for those whose culture stipulates that

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their clothing cover all of their skin or for those who use sunscreen whenever they go outside. All of these factors decrease the ability of the body to synthesize Vitamin D3 via UVB absorption.[6]

Current research indicates a possible link between decreased calcium/Vitamin D levels in the body and low bone mineral density (BMD). Low BMD is used as one of the main diagnostic criteria for osteoporosis.[7] The possible connection between a vegan lifestyle, low BMD and the development of osteoporosis has important societal as well as medical implications. Low BMD and the development of osteoporosis often lead to fractures—hip, spine and wrist fractures being the most common.[8] Incidence of hip fractures results in costly medical procedures that tax the health-care system (an estimated $10–20 billion is spent per year in the USA on the treatment of osteoporotic fractures[9]) and increased morbidity and mortality rates.[8]

This information raises three important questions: (i) Do vegans have lower-than-recommended levels of calcium/Vitamin D? (ii) Do vegans have lower BMD than their non-vegan counterparts? (iii) Are vegans at a greater risk for fractures than non-vegans? This paper will explore several studies regarding vegan diets and calcium/Vitamin D intakes, the BMDs of those choosing a vegan diet and the incidence of fractures in those following a vegan diet compared with omnivores and lacto-/lacto-ovo-vegetarians (vegetarians who consume some animal sources of protein). The validity and reliability of the results of these studies will be critically examined for their ability to answer the questions listed above.

LITERATURE SEARCH

Literature on vegan diets/lifestyles, calcium/Vitamin D, BMD and osteoporosis was gathered from various sources, including, but not limited to, Internet search engines and websites, electronic databases and library resources. These resources were used to provide background information and highlight the significance of exploring the issue of veganism and potentially related mineral and vitamin deficiencies.

Literature for this analysis was gathered, in part, through MEDLINE. The key words 'vegan' and 'osteoporosis' were used, resulting in 31 hits. Recent research studies containing subjects and data appropriate for addressing the three posited questions were obtained. Additionally, reference lists within said studies were polled for other useful research publications.

CINAHL was searched using the combination of the key words 'vegan' and 'osteoporosis' as well as the combination of 'vegan' and 'bone mineral density'. These searches resulted in four and five hits, respectively. No original research publications were retrieved from this database search.

The PsychINFO database was also searched to provide a well-rounded foundation of knowledge on which to draw. This database was selected for additional data on the possible psychological and biobehavioural components that might influence an individual's cognitive decision to choose a vegan diet/lifestyle. The key word 'vegan' was entered into the database, and resulted in 29 hits. Again, recent research publications determined to be relevant to the questions at hand were obtained and the reference lists were also scanned for additional resources.

ANALYSIS

Calcium/Vitamin D

The calcium levels of vegans were found to be consistently lower than the Recommended Daily Allowance (RDA)/Recommended Nutritional Intake (RNI).[10] Sellmeyer *et al.* reported a mean calcium intake of 662 ± 356 mg[11] and Fontana *et al.* reported a mean calcium intake of 579 ± 260 mg.[12] The RDA for adults is 1000–1200 mg.[13] This would indicate that, on average, the vegans in these studies are ingesting only 60% and 53% (respectively) of the RDA of calcium.

The results on the bioavailability of Vitamin D were conflicting. Outila *et al.* showed that: (i) the bioavailability of 25-hydroxyvitamin D (the active form of Vitamin D found in the blood that is essential for the utilization of calcium[6]) was highly correlated with the ingestion of dietary Vitamin D ($P = 0.02$); (ii) vegans ingested significantly ($P < 0.001$) lower levels of dietary Vitamin D than non-vegans; and (iii) vegans had lower blood levels ($P = 0.01$) of 25-hydroxyvitamin D than non-vegans.[14] None of these findings are surprising considering that levels of 25-hydroxyvitamin D are regulated by Vitamin D3, a nutrient that is available only in diets that contain animal products. However, it is worthy to note that this study was conducted in Finland, which is located at a latitude 60 degrees North, well above the established northern border for the optimal UVB synthesis of Vitamin D (42 degrees North).[6] (Outila *et al.* hypothesized that they would find lower levels of 25-hydroxyvitamin D in practising vegans during the winter months in Finland.[14])

Conversely, a study conducted in St. Louis, MO (latitude 38 degrees North), showed that vegan subjects had higher levels of 25-hydroxyvitamin D than those consuming a diet that included animal proteins. The authors commented on this finding, relating the increased levels of 25-hydroxyvitamin D to reports from the vegan subjects that they made extra efforts to expose themselves to sunlight.[12]

Bone mineral density

Bone mineral density of the hip was the most consistently reported statistic in this data set.[12,14–16] All studies showed a statistically significant correlation between decreased animal protein ingestion and low BMD in the hip area ($P \leq 0.05$). Methodologies used by the researchers for calculating both animal protein intake and BMD of the hip were similar (questionnaires and X-rays, respectively). This consistency in the results and the methodologies is powerful when considered in light of the varied geographic locations of the studies (Finland, Taiwan and the USA).

However, even consistent results in both calcium levels and BMD cannot cause a direct correlation between low calcium and low BMD to be drawn. Alternative hypotheses exist. One of the more prominent hypotheses surrounds the acid–base balance in the blood, where abundant ingestion of animal protein causes acid overload and forces the bones to seep calcium into the blood in order to maintain a proper pH balance.[11,15,17]

Risk factors for fractures

The statistics from this data set also focus on the hip: the rates of bone loss in the hip;[11,15] relative risk for experiencing a fracture of the hip;[11,18] and the actual incidences of hip fractures.[17] The results are so varied and conflicting that a general consensus cannot be reached. The findings show relationships to increased animal protein intake and increased bone loss[11] as well as increased animal protein intake and the decreased risk for hip fracture.[18]

Another key variable noted among these (and other) studies was the relationship between weight and the risk for hip fracture. An increased body mass index (BMI) was found to protect against hip fracture,[19] where lower BMI was indicative of greater risk for hip fracture.[18] The hypothesis behind these two correlations is that body mass (in the form of actual body weight) puts enough stress on bones to maintain optimal BMD whereas the lack of weight (in the form of decreased muscle mass and fat) results in conditions insufficient to preserve optimal BMD. It is conjectured that this lack of muscle mass might decrease coordination, contributing to an individual's risk for falling, leading to an increased incidence of fractures.[18]

DISCUSSION

Overall, there are issues with the generalizability of the studies because of sample size and subject characteristics. Sample sizes for the studies that reported dietary intakes of calcium and Vitamin D were $n \leq 35$. Use of a small sample size when monitoring individual food intake and patterns enables researchers to feasibly complete the study; however, it does not control for the possibility of a confounding factor that might contribute to the variable of interest being measured. This decreases the ability to apply the results of the studies to more general populations.

Subject characteristics in the studies included female gender, postmenopausal status and Caucasian ethnicity. The reasons for selecting these subject characteristics as inclusion criteria vary among studies, but include: the importance of the issue to the elderly population;[15] the availability of subjects;[11] and the ability of subjects to participate and complete the study.[11,14] As was mentioned with the issue of sample size, in these studies, there was a trade-off of generalizability for ease of research conduction.

Two specific issues surround the ability of these studies to adequately answer the analytical questions raised in this paper. The first issue centres on the measurement of orally ingested calcium and Vitamin D. In this analysis, all studies in which dietary intakes of calcium and Vitamin D were reported utilized subject self-reporting methods for data collection. Self-reporting data collection tools are highly susceptible to 'response biases—that is, the tendency of some respondents to distort their responses'.[20] These very subjective measurement tools are often questioned as to reliability and validity.

Regardless of the reporting method used, the measurements of the dietary intake of Vitamin D in vegans were insufficient for determining the level of 25-hydroxyvitamin D in the blood. A vegan diet eliminates all possible dietary food sources of Vitamin D3 (which is converted into usable 25-hydroxyvitamin D). Additionally, with the exception of Frassetto *et al.*,[17] more than half of the studies collected for this analysis (63%) were conducted in locations that lie above a latitude of 42

degrees North, restricting the ability of subjects to increase their levels of Vitamin D3 (and subsequently 25-hydroxyvitamin D) by UVB synthesis, thereby impacting the data gathered.

Most importantly, there is evidence that calcium, in conjunction with family genetics, determines the maximum amount of bone an individual will achieve by the end of young adulthood (peak bone mass).[8,16] However, a direct link between calcium deficiency, low BMD and osteoporosis has not yet been established.[8] This information, along with the possibility of alternative hypotheses for the development of low BMD, renders this analysis unable to adequately answer the question of lower calcium/Vitamin D levels in vegans.

The second issue specific to the analytical questions raised in this manuscript involves the varied results of hip fracture studies. Not only was this analysis unable to formulate a conclusion based on the available data, there are some concerns about the government funding received by some of the studies on bone loss and the risk/incidence of hip fracture. One study received funding from the United States Department of Agriculture[15] and another received funding from the United States Dairy Council.[18] Research that arrives at conclusions that support the agency that provided funding for the project is subject to severe scrutiny regardless of the reputations of the researchers and the integrity of the work they have produced in the past. It is natural and, even prudent, to be suspicious of collaborations that could produce results that would be self-serving to the goals and interests of the funding sponsor.

SUMMARY

Questions regarding blood calcium/Vitamin D levels and increased risk for bone fractures in vegans remain largely unanswered by the current literature. However, the same literature consistently shows lower BMD in vegans. This fact alone supports the need for further investigation of vegan diets/lifestyles. Low BMD is one of the main diagnostic criteria[7] and the best indicator of risk for osteoporosis,[19] a disease that can result in life-threatening and costly ramifications for the individual patient and for society as a whole.

Further research, using more quantitative methods of measuring calcium/Vitamin D intake, is necessary to determine the true status of calcium/Vitamin D levels in vegans. More studies need to be conducted in geographical areas that lie between the latitudes of 42 degrees North and 40 degrees South. This will provide more data for a proper analysis of the potential bioavailability of 25-hydroxyvitamin D by means of UVB synthesis of Vitamin D3 and result in more helpful guidelines for vegans who wish to supplement their nutritional status by using this alternative non-animal resource. More research involving young adult subjects (specifically men) should be conducted in order to observe whether and how bone density in this population changes over time. Finally, research free of the possible bias introduced, either innocently or knowingly, by government funding needs to be undertaken to definitively answer the question of correlation between animal protein intake and incidences of bone loss and hip fracture.

IMPLICATIONS FOR NURSING

While providing patient care, Advanced Practice Nurses often deal with issues regarding diet. Until more solid links between calcium, BMD and osteoporosis are established, practitioners must counsel their patients using currently accepted clinical guidelines.

For those practitioners dealing with children and adolescents, the importance of building strong, healthy bone must be stressed because achieving peak bone mass plays a critical role in the prevention of fractures.[8] Proper calcium intake and adequate exercise should be encouraged.

Practitioners counselling vegans and those with dietary restrictions (self-imposed or medically necessary) should discuss with their patients the importance of adequate calcium intake from alternative, non-traditional sources. For the vegan population, increased exposure to sunlight, especially in the winter months and in those areas around 42 degrees North and 40 degrees South, is essential. The lack of food sources high in Vitamin D3 necessitates higher-than-normal UVB exposure to ensure that the body maintains adequate Vitamin D3 levels. Without this critical nutrient, even the most optimal calcium levels will be inadequate in maintaining bone mass. This need for a concerted effort for adequate sunlight exposure might also be applicable to those who are dark-skinned, to the elderly and to those persons who cover themselves completely when outside.

For all patients, an adequate intake of protein (animal or vegetable) and exercise to maintain optimal weight and muscle mass should be encouraged. These recommendations will serve all patients equally well, not only in the possible prevention of osteoporosis but also in the prevention of many other life-limiting illnesses.

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