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Vitamin D status in North America

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In the United States (U.S.), serum 25(OH)D levels have been assessed in a representative sample of 20,289 non-institutionalised, civilian males and females in the National Health and Nutrition Examination Survey over the period of 2002-2004 (NHANES 2002-2004) [1, 2]. Among males in selected age categories of 1-5 years, 20-49 years, and 70 years and older, the prevalence of 25(OH)D levels considered by some to be deficient (<37.5nmol/L) were 2%, 13% and 11%, respectively [1]. The proportions of males with levels below 50nmol/L for the same age groups were 8%, 29% and 27%, respectively. The proportions with serum 25(OH)D concentrations below the level considered by many to be optimal for older adults (<75nmol/L), for the same age groups, were 50%, 73% and 78%, respectively. Among females, 25(OH)D levels below 37.5nmol/L were present in only 3% of those age 1-5 years, but more common in young adults age

20-49 years (19%) and in women age 70 years and older (16.5%). Serum 25(OH)D levels below 50nmol/L were present in 8.5%, 35%, and 34% of females in the same three age groups, respectively. The proportions with serum 25(OH)D levels below 75nmol/L were 56%, 73%, and 77% in these age groups, respectively.

Within these 25(OH)D categories, however, prevalence of low serum 25(OH)D levels vary dramatically by race/ethnicity. For example, among males aged 70 years and older, the prevalence of levels below 50nmol/L was 23% for non-Hispanic whites, 45% for Mexican Americans and 58% for non-Hispanic blacks. By age 70 years and older, the prevalence of levels below 75nmol/L in these three groups were 76%, 88%, and 93%, respectively. Among women, the corresponding prevalence of values below 50nmol/L were 28.5%, 55%, and 68% and of values

below 75 nmol/L were 73%, 89%, and 95%, respectively. Information on the other age groups and on the impact of season on 25(OH)D levels is also available [1].

Comparison of these values with those in the previous NHANES III conducted in 1988-1994 reveals that secular changes in the 25(OH)D levels have occurred over the last 10 years [1, 3]. The more recent 25(OH)D levels are 5-20 nmol/L lower than those in the 1988-1994 survey [3]. After adjustment for the contribution of assay differences, the newer values remain 5-9 nmol/L lower. The lower values, present more frequently in males than in females, have been explained by the combination of an increase in body mass index, a decrease in the consumption of milk, which in the U.S. is routinely fortified with vitamin D, and more widespread sunscreen use [1, 3].

National survey data are not available for institutionalised individuals and other high risk groups in the U.S., but investigator initiated studies reveal that 25(OH)D levels are, as expected, low in those that do not routinely take supplements. For example, in institutionalised elderly not taking vitamin D supplements, 30% had 25(OH)D levels below 37.5 nmol/L [4]. In acute hip fracture patients admitted to a hospital in Boston, the mean serum 25(OH)D level was 32 nmol/L and half of the patients had extreme vitamin D deficiency, defined as 25(OH)D levels of 30 nmol/L and lower [5]. Of 1536 postmenopausal women residing throughout the US who were taking pharmacotherapy for osteoporosis, 18% had 25(OH)D levels below 50 nmol/L and 52% had levels below 75 nmol/L [6].

In summary, despite growing awareness of the multiple health benefits of an adequate vitamin D status, vitamin D insufficiency abounds and is a growing problem in the U.S.

Vitamin D is synthesized in the skin after exposure to specific wave bands (290-310 nm) of ultraviolet light from the sun or it can be obtained through the diet. However, because few foods provide a natural source of vitamin D and because fortification of foods with vitamin D may be unreliable, skin synthesis is thought to constitute the major source. People living in countries at higher latitudes are more prone to seasonal vitamin D insufficiency because sunlight

in the winter does not promote vitamin D synthesis. An early study by Vieth and colleagues [7] showed that in Canada serum 25(OH)D changed substantially with season. They divided the year into summer/ winter halves. The prevalence of low 25(OH)D concentrations was greatest during the 'winter' half of the year (November to April). However, it was only during the summer phase (May to October) that there was a significant relationship between multivitamin use (containing some, usually 400 units of vitamin D) and serum 25(OH)D. Contrary to expectations from nutritional recommendations this study showed that there was no relationship between vitamin D intake from milk and multivitamins and serum 25(OH)D during the winter. Moreover, the Vieth laboratory has indicated that the average serum 25(OH)D concentrations of Canadians are similar to those of Europeans (whose diets are not fortified with vitamin D) [8]. It has been suggested that the similarities in Canadian and European so-called "normal" ranges for 25(OH)D suggest that the vitamin D added to milk in Canada, but not in Europe, could be of marginal value in adults to increase the 25(OH)D level only modestly.

However, as mentioned diet is not a reliable source of vitamin D and it has been shown in Boston (latitude 42° North) that sun irradiation is inadequate to generate vitamin D in vitro from November through February [9]. In Edmonton, Alberta (latitude 53° 30' North) this period extends from October through March. Hanley and colleagues determined the patterns of seasonal variation in 25(OH)D as well as the prevalence of vitamin D insufficiency (defined as a 25(OH)D < 40 nmol/L) in a population of healthy men and women living in Western Canada (Calgary). They measured vitamin D levels at three-monthly intervals, i.e., February or March, May or June, August or September and November or December. There was a significant rise in serum 25(OH)D during the spring (May or June) and summer (August or September) relative to the winter values (the other two periods). Several other independent predictors of the 25(OH)D were increasing age and increasing BMI. Travel to lower latitudes (below 42° North) was associated with significant increases in 25(OH)D during the spring and summer months. This study, therefore, documented the seasonal variations in levels of 25(OH)D and the high prevalence of vitamin

D insufficiency during the autumn and winter in an ambulatory population of healthy western Canadians situated at 51°0, 7' North. Previous studies in Canada had been limited mostly to elderly people living in institutions, low income elderly people and young women [7-9]. Moreover, regardless of season increasing age was associated with lower levels of 25(OH)D. The conclusion from this Canadian study using a conservative definition of vitamin D insufficiency (<40nmol/L) is that 34% of the subjects had vitamin D insufficiency at least one point during the year. Raising the vitamin D insufficiency threshold by only 10nmol/L to 50nmol/L nearly doubles the proportion of the study population who would be classified as having vitamin D insufficiency (61%) on the basis of this 25 hydroxy vitamin D level. However, it should be pointed out that this study may not be generalizable to other Canadian populations since the study sample was predominantly white and may not reflect the diverse and multi-ethnic communities such as those in other Canadian cities, for example, Vancouver or Toronto. Other interesting features of this study are that Calgary receives more hours of sunshine per year than any other Canadian city, particularly in the fall and winter. Moreover, at an elevation of 1,077 meters, Calgary residents are situated at a considerably higher altitude than most other Canadians. It has been demonstrated that with every 300 meter increase in elevation there is an approximately 8-10% increase in ultraviolet B radiation. Thus, given that there are more sunshine hours in Calgary at a higher elevation, it is likely that the seasonal decreases that were observed in late fall and winter underestimate those that may be seen in other Canadian populations.

The most recent study by Vieth's group (unpublished observations) has looked at low winter time vitamin D levels in healthy young adults of diverse ancestry living in the Toronto area. More than 93% of the total sample of 107 healthy adults had concentrations below 75nmol/L. Almost three quarters of the subjects had concentrations below 50nmol/L. The group with the greatest prevalence of vitamin D insufficiency were those of non-European (non-Caucasian) ancestry. Major factors influencing 25(OH)D levels in this study were vitamin D intake and skin pigmentation. In this sample 22% of individuals of European (Caucasian) ancestry had 25(OH)D levels <40nmol/L. However, 78% of individuals of East

Asian ancestry and 77% of individuals of South Asian ancestry had 25(OH)D concentrations lower than 40nmol/L. This research suggests that for these young adults living in southern Ontario that the currently recommended adequate intake of vitamin D (RAI = 200 IU per day) is not met by a large proportion of young adults. Moreover, this low intake of vitamin D is insufficient to ensure the suggested optimal circulating 25(OH)D levels of around 75nmol/L.

In summary, available data indicate that vitamin D concentrations are low in many otherwise healthy Canadian adults, particularly during winter months. An early study of young women (18-35 years of age) in Toronto found that 21% of white women, 31.9% of non-white women (a group which combined First Nations peoples, South Asian, Indo Asian and East Asian ancestries) and 25% of black women had serum concentrations below 40nmol/L. The Calgary data demonstrated that in men and women of mostly European ancestry, 20% had serum concentrations below 40nmol/L, 39% had serum concentrations below 50nmol/L and 86% had serum concentrations below 80nmol/L.

The Canadian Multicentre Osteoporosis Study (CaMos), a prospective epidemiology study of 10000 randomly selected people from across Canada is in the process of measuring 25(OH)D levels (among other analytes) which will help shed light on the vitamin D situation across Canada.

For further information, the reader is referred to:

A. Mithal, D.A. Wahl, J-P. Bonjour et al. on behalf of the IOF Committee of Scientific Advisors (CSA) Nutrition Working Group. Global vitamin D status and determinants of hypovitaminosis D (2009) *Osteoporosis International*, in press

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