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The Vitamin D Status Among Tibetans

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ABSTRACT

UVB from the sun and intake from food are the only human sources of vitamin D. Tibet is a unique region for comparisons of these sources: (1) it lies at a low latitude and at a high altitude and has very large annual fluences of UVB; (2) the traditional Tibetan food is poor in vitamin D. Blood samples were taken from 63 persons of different age, with different occupations and staying at different places. UVB doses at these places were measured. The samples were analyzed by a standard radioimmune assay for determination of the serum concentration of 25 hydroxyvitamin D (25(OH)D). The main finding was that among nomads, there seems to be severe vitamin D deficiency (serum levels of 25(OH)D $<$ 30 nM). We tentatively propose that the low level of 25(OH)D of nomads is related to their clothing and sun exposure habits. For persons of other occupations (students, teachers and farmers) the levels are higher, although a significant fraction of these persons also have lower levels than 75 nM, by many regarded as a limit for insufficiency related to a number of negative health conditions. The annual dose of vitamin D-generating UVB is about five times larger in Lhasa than in Oslo. Despite this, the average vitamin D status seems to be similar, except in the case of nomads. This phenomenon is certainly related to food habits. In conclusion, the 25(OH)D status among nomads in Tibet appears to be alarmingly low. However, for people of other occupations the status is more normal.

INTRODUCTION

Worldwide, the negative health effects related to an inadequate status of vitamin D are being focused on. Earlier, mainly bone disorders, such as rickets and osteomalacia were studied (1,2). Recently, however, a large number of health disorders have been brought to attention: Cancer, diabetes, rheumatoid arthritis, multiple sclerosis, coronary/heart diseases and influenza are among the conditions studied (3–8). The vitamin D status is usually assessed by measuring the level of 25 hydroxyvitamin D (25(OH)D) in serum (9). Deficiency of vitamin D is often defined as levels below 50 nM. Insufficiency of vitamin D is 51–74 nM (5,9).

It is well known that humans have two sources of vitamin D: solar UVB (radiation in the wavelength region 280–315 nm), and food, mainly fat fish and fish liver (10). Skin color plays a role, as naked, black skin needs about six times larger UVB doses than naked, white skin to generate the same amount of vitamin D (11–13).

This paper considers the relative roles of solar UVB and food as sources of vitamin D. Data from Tibet will be valuable inputs in this discussion: In Tibet the annual fluence of UVB is very large, due to the low latitude and the high altitude. The seasonal variation is relatively moderate and even in the winter there is enough UVB radiation to produce sufficient vitamin D. Recently Holick *et al.* reported the effects of altitude on previtamin D3 synthesis (14). On the other hand, the food supply of the vitamin is expected to be low. Major food sources in Tibet are barley, yak meat and butter, vegetables and nonfat fish, which contain little or no vitamin D (15). Thus, solar radiation falling on naked skin is expected to be the main source, notably as the skin color of Tibetans is rather light for the latitude, and as practically no UVB-emitting sunbeds are yet available in the region. Sun exposure habits, clothing habits and differences in fluence rates of UVB from place to place are likely to be the major determinants for the vitamin D status. For the first time, 25(OH)D measurements from Tibet are being reported, addressing the above-mentioned issues. Data for solar radiation at different locations in Tibet have also been determined and are included in the investigation.

MATERIALS AND METHODS

Blood samples were taken from 63 persons living in different places in Tibet, as shown in the Tibet map on Fig. 1. The work was conducted in accordance with the ethical standards of China and informed consent was obtained from each person. The sampling of blood took place between 28 October and 23 November 2007. Males and females of different age and different occupations were included, as given in Table 1. The blood samples were frozen and transported to Beijing, where they were analyzed by the Beijing Furui Bio-engineering Company (Haidian District, Beijing, China). A standard radioimmune assay was employed to determine the serum concentrations of 25(OH)D. In brief, the radioimmune assay reagents box (including ^{125}I-25(OH)D, 25(OH)D antibody and precipitation complex) was used and kept at the temperature of 2–8°C. The concentrations of standard are in the range of 7.5–250 nM. For each blood sample, at least 50 μL serum was extracted for the measurement. The reference values by the means of this method are 22–117 nM.

The data are given in Table 1, where the levels of 25(OH)D are expressed in nM. UVB determinations were carried out as described earlier (16). Briefly, global solar exposure (direct + diffuse exposure)

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Figure 1. A map of Tibet, showing the locations where the serum samples were obtained. Relevant latitudes are marked.

Table 1. Vitamin D status in five places in Tibet.*

Place	Latitude (°N)	Altitude (m)	UVB dose (rel. units)	Occupation (n)	Age (mean ± SE)	25(OH)D nM (mean ± SE)	Prevalence of deficiency (%) < 30 nM	< 75 nM
Shigatse	29°19′	3840	26236	Farmers (20)	43 ± 4	81 ± 4	0	40
Lhasa	29°39′	3670	26643	Students (20) Teachers (5)	27 ± 2	58 ± 4	4	80
Tingri	28°34′	4330	21137	Farmers (6)	33 ± 6	67 ± 11	17	67
Chonggye	29°02′	3770	24347	Farmers (6)	43 ± 5	46 ± 11	17	83
Amdo	32°14′	4700	24211	Nomads (5)	34 ± 6	26 ± 4	80	100

25(OH)D = 25 hydroxyvitamin D. *The UVB dose is the sum of the doses for August, September and October 2007.

was calculated, approximating the human body by a horizontal cylinder, excluding top and bottom. Total ozone columns measured by the TOMS satellite instruments were used in the calculations. The 7-dehydrocholesterol absorption spectrum given by Galkin and Terenskaya (17) was used and the human body was approximated by a vertical cylinder, excluding bottom and top. We earlier argued that this is a better representation than a flat, horizontal surface as used by most other investigators (16). As the maximal concentration of 25(OH)D in serum is reached approximately 7 days after a UVB exposure (18), and as the half-life of 25(OH)D in serum is about 2–3 weeks (19,20), the UVB exposures are given as the sum of the doses for August, September and October 2007.

RESULTS

All relevant, available numerical results are given in Table 1, where 25(OH)D values and UVB doses are given. Weights and heights of all participants were measured, enabling us to calculate body mass indexes (BMIs). We had no opportunity to measure serum PTH, albumin and calcium. Figure 1 is a map of Tibet showing the sites where we obtained the blood samples. Figure 2 shows all 25(OH)D values plotted as functions of BMI, with different symbols for different places in Tibet. One of the 63 measurements is omitted: A nomad in Amdo had a level of 25(OH)D that was three times larger than the average value, and was excluded for this reason, as a mistake almost certainly had been done with his sample. Unfortunately, we were not able to repeat the sampling. Figure 3 shows a bar diagram for students/teachers, farmers and nomads. The values for the nomads are significantly lower than those for the three other occupation groups.

Figure 4 shows the rate of vitamin D-generating UVB for each month of the year in Oslo and in Lhasa, calculated as described in Materials and Methods. Figure 5 shows the rate of UVB dose as a function of time of the day on 21 June (midsummer) and on 15 October (just before start of our blood sampling). Data for Lhasa and Oslo are given, as they may be useful for comparisons of the vitamin D status in Oslo and in Lhasa. The daily variations are also important to know when health recommendations of sun exposure are to be given.

DISCUSSION

Traditional Tibetan food, as well as food on the market in Lhasa, is poor in vitamin D, being practically devoid of fat fish. It is well known that meat, barley, vegetables and even

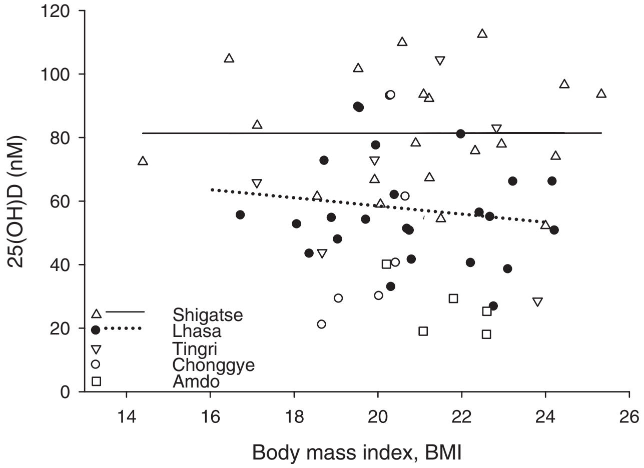

Figure 2. 25 Hydroxyvitamin D (25(OH)D) values from all locations, shown with different symbols, as functions of body mass index (BMI).

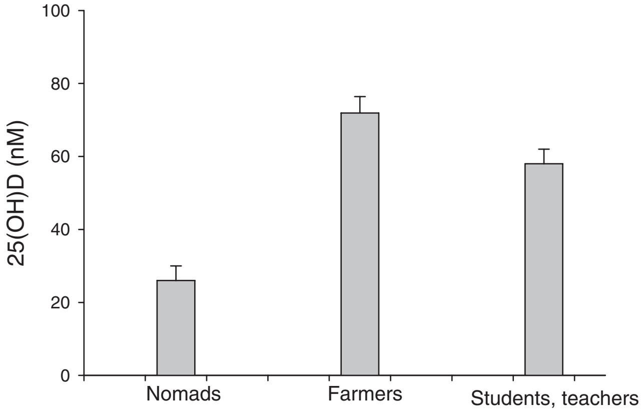

Figure 3. A bar diagram, with standard errors, for average 25 hydroxyvitamin D (25(OH)D) values for people of different occupations.

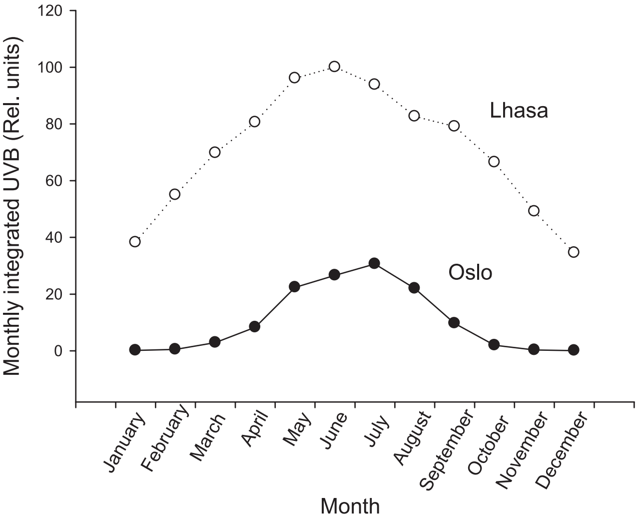

Figure 4. The rate of vitamin D-generating UVB per month for Lhasa and Oslo, determined as described in Materials and Methods.

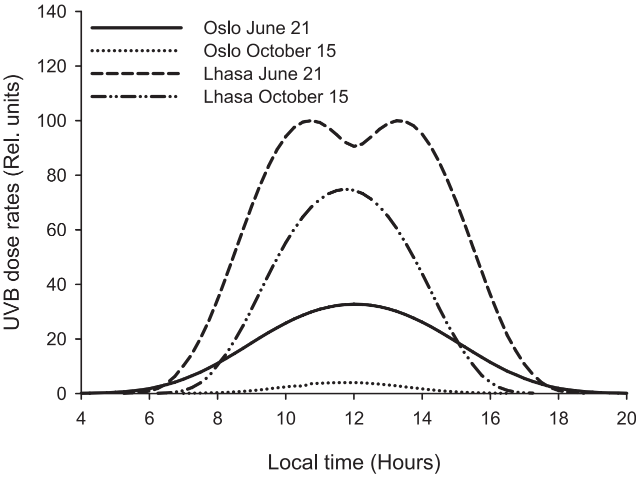

Figure 5. The rate of UVB dose shown as functions of time of the day in Lhasa and in Oslo on 21 June and 15 October 2007.

milk and eggs contain too little vitamin D to satisfy human needs (10). Thus, the main source of vitamin D in Tibet is solar radiation falling on naked skin. This means that clothing habits, outdoor stay between 0800–0900 h in the morning and 1500–1600 h in the afternoon are of major importance. Tibetans rarely expose more of their body than face and hands, which seems to be sufficient at these fluence rates, as few others than nomads are severely 25(OH)D deficient. Several parameters related to solar radiation explain this: First, the vitamin D production rate in Tibet is high, as demonstrated in Figs. 4 and 5, where Lhasa and Oslo are compared. In Lhasa vitamin D is produced throughout the year, while in Oslo no production takes place in the months between October and March. As a result of this, vitamin D deficiency can occur in the winter in Norway (21), while in Lhasa the UVB fluence rate in midwinter is as large as that in Oslo in midsummer (Fig. 4). In our earlier work, we found average 25(OH)D levels of about 55–60 nM in Oslo (22). The low winter temperature in Lhasa (typically, the winter daily averaged temperature in Lhasa is around −1°C), may play a role in outdoor life, although probably not a major one, as people expose only face and hands. Second, the skin of Tibetans is only moderately dark, in fact, less dark than one may expect for such a low latitude. The low temperature and the shortage of vitamin D-rich food are probably the evolutionary reasons for the light skin color.

Surprisingly, the levels of 25(OH)D at the end of the summer are similar in Tibet and Norway, despite the large differences in solar fluence rates (23–25). This may be explained by the differences in clothing habits, sun-seeking patterns and skin color, as Norwegians have lighter complexions and higher intentional sun exposures.

The most important finding in the present work is that there seems to be severe 25(OH)D deficiency among nomads. Thus, 80% had lower levels of 25(OH)D than 30 nM. This is certainly not due to any lack of vitamin D-generating solar radiation. In Amdo, where the nomads live, the UVB dose for the 3 months before serum sampling was similar to that in the other places, including Lhasa (Table 1). The food of the nomads consists of samba, wheat, yak meat, yak butter, yak yoghourt and moderate amounts of vegetables. All these food sources are poor in vitamin D. We propose that the reasons for their

25(OH)D deficiency are that they tend to avoid midday sun exposure and that they carefully cover most of their body when outdoors. There was no difference in average age, or in average BMI between the nomads and the other groups (Fig. 2, Table 1).

In Norway we found that the 25(OH)D status decreases with increasing BMI (Z. Lagunova, A. C. Porojnicu, F. Lindberg, S. Hexeberg and J. Moan, unpublished). The present data do not reveal any such trend (Fig. 2). However, the sample size in the present work is small, and the spread of BMIs is too small to allow any conclusion to be drawn.

There seems to be no large difference in 25(OH)D level between different occupations, with the exception of nomads. Neither can we trace any differences in serum concentrations of 25(OH)D to differences in ambient UVB doses.

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