

Human Vitamin D Deficiency in Tibet

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Abstract

Vitamin D contributes significantly to human bone formation, growth, metabolism and disease prevention. During 2007-2009 and 2012-2013, we measured serum calcidiol (25-hydroxyvitamin D₃, 25-(OH)D) in Lhasa, Shigatse, Tingri, Nagqu and other places of Tibet in order to get the status of the overall level of vitamin D in Tibet. We also studied influence of area, occupation, age, gender, season and other factors on the serum 25(OH)D level. Results of our study indicate that: 1) in Tibet, the overall serum concentration of calcidiol is in deficiency range (25(OH)D level is 12.25 ng/ml); 2) the serum level of 25(OH)D in different regions is generally the same; 3) the serum level of 25(OH)D in young and middle-aged people is 20% higher than that in elder; 4) the level of 25(OH)D in male is slightly higher than in female; 5) the level of 25(OH)D in summer is significantly higher than that in winter; 6) there are obvious differences in serum level of 25(OH)D among tested subjects with different occupations.

Keywords

Vitamin D, Altitude, Tibet, Solar UV Radiation

1. Introduction

Vitamin D plays a very important role for the human health. It has five different forms. The most important ones are vitamin D₂ (ergocalciferol) and vitamin D₃ (also known as cholecalciferol) [1].

Vitamin D is one of the most crucial regulators for metabolism of calcium and phosphorus [2]. In 1923, Harry Steenbock proved that ultraviolet radiation increased vitamin D content for treatment of human rickets and osteomalacia. Now, vitamin D is the preferable drug for prevention of osteoporosis due to its ability to enhance bone density and strength [3] [4] [5].

A number of scientific research results show that vitamin D can prevent excessive cell proliferation to reduce the risk of cancer [1] [6]. Moreover, Johan Moan *et al.* found that high vitamin D level at the time of diagnosis of cancer seemed to give an increased survival rate [7]. Alina Porojnicu *et al.* reported that vitamin D has a potential prognostic factor in Hodgkin's lymphoma. They raised their standpoint by analysis of the Norway national data from 1964 to 2000. Fatality of patients diagnosed with Hodgkin's lymphoma in the fall was 20% lower than those who diagnosed with Hodgkin's lymphoma in winter. Furthermore, the improved autumnal survival rate was much higher for patients younger than 30 years [8].

Adequate vitamin D could strengthen immunity [2] [9], prevent and treat heart diseases [5] [10], ensure better development of fetus [11]. Vitamin D could also treat hypertension, diabetes, Alzheimer's disease and other diseases effectively [5] [12]. In recent years, research groups point out that vitamin D can prevent tooth decay [13]; vitamin D deficiency not only makes people feeling of fatigue [14] [15], but also can make people depressed or even cause depression [16]. A large number of studies further point out that many diseases are accompanied by vitamin D deficiency, and the vitamin D level can indicate the severity of some certain diseases [17]. Therefore, it is essential to improve the level of vitamin D.

Vitamin D from the diet or dermal synthesis from sunlight is the only two ways in biologically inactive [12] [18], and the latter is the most important way. Tibet has abundant solar energy resources since it lies at a low latitude and at a high altitude. However, because of its high altitude and tough circumstances, the research of vitamin D is developed slowly in Tibet. In 2007, for the first time, Gelsor Norsang *et al.* carried out the study of vitamin D in Tibet [19]. The results showed that the level of human vitamin D in Tibet was relatively low, and the levels were different in different occupation.

From 2008 to 2013, further study on vitamin D in Tibet was performed continuously. Blood samples were collected from several places in Tibet and the serum calcidiol (25(OH)D) was measured. The influence of factors such as regions, seasons, occupations on Tibetans vitamin level was studied and analyzed. Suggestions in prevention and treatment of disease by using vitamin D were given to Tibetans.

2. Materials and Methods

During April, June, August, November of 2008 and February, January of 2009, blood samples were taken from 16 persons six times (7 males and 9 females. 81 blood samples in total were taken ultimately, because some volunteers could not follow the measurements in the end) in the Nicang village of Shigatse city in Tibet, as illustrated in **Table 1**. During 2012 and 2013, blood samples were taken from 290 persons lived in different places in Tibet. Males and females of different ages and different occupations were included (blood samples of

Table 1. Sampling of Vitamin D in Shigatse, Tibet during 2008 and 2009.

Sampling time	Simples	Gender(n)		Occupation
		Male	Female	
2008.04	16	7	9	Farmers
2008.06	16	7	9	
2008.08	13	6	7	
2008.11	10	3	7	
2009.01	12	7	5	
2009.02	14	8	6	
Total	81	38	43	

children and adolescents were not taken as not be permitted by residents), as illustrated in **Table 2**.

The blood sample was centrifuged at 1000 rpm for 15 min after letting it stand at room temperature for 10 min. Then the serum (upper layer) was transferred to special Eppendorf tube. For each blood sample, at least 50 μ l serum was extracted for the measurement. The serum 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 [19].

3. Results

Vitamin D deficiency can lead to a variety of diseases. However, there is no unique criteria of serum levels of 25(OH)D for human health. In this article, we use the standard set by Osteoporosis Committee of China Gerontological Society (published in 2014, same with the American Institute of Medicine [20]), which defined vitamin D deficiency at serum levels of 25(OH)D less than 30 nM, vitamin D inadequate is at serum levels of 25(OH)D between 30 and 50 nM, vitamin D adequate is at serum levels of 25(OH)D greater than 50 nM.

The serum 25(OH)D level of blood samples taken from Lhasa and surrounding towns, Nagqu, Tingri, Shigatse (Nicang village and Bianxiong village) during 2012 and 2013 were analyzed (**Figure 1**). It is clear that the vitamin D level in Tibet is in severely low range. More than 90 percent of residents are in the deficiency range or inadequate range. In 2012, among 162 volunteers in the survey, only 16 volunteers are in adequate range, which accounted for only 9.88% of the total; 82 volunteers are in inadequate range, which accounted for 50.62%; 64 volunteers are in deficient range accounted for 39.51% of the total. While, in 2013 more than half of volunteers are in deficiency range.

Tibet is located in the Qinghai Tibet Plateau, with an average altitude of 4000 meters above sea level, varying largely in different regions. We analyzed the levels of serum 25(OH)D in different regions. **Figure 2** showed that the average levels of serum 25(OH)D were all in deficiency range in Lhasa (12.6 ± 5.0 ng/mL),

Table 2. Sampling of Vitamin D in Tibet during 2012 and 2013.

Sampling Location	2012				2013			
	Occupation(n)	Gender(n)		Age(n)	Occupation(n)	Gender(n)		Age(n)
		Male	Female			Male	Female	
Lhasa	Farmers(29)				Farmers(29)			
	Teachers(5)	23	28	<30(43)	Teachers(1)	14	19	<30(23)
	Students(17)			30~ < 40(26)	Students(3)			30~ < 40(17)
Shigatse	Farmers(36)	14	22	40~ < 50(32)	Farmers(40)	14	26	40~ < 50(33)
Tingri	Farmers(33)	7	26	50~ < 60(26)	Farmers(15)	8	7	50~ < 60(27)
Nagqu	Herdsmen(42)	26	16	≥60(35)	Herdsmen(40)	20	20	≥60(28)

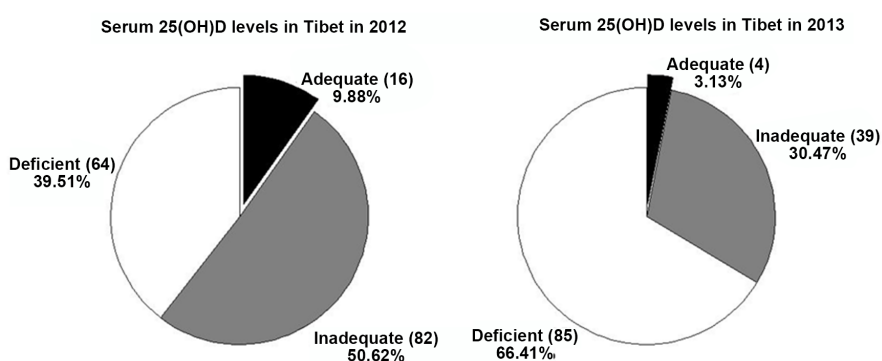


Figure 1. The overall levels of serum 25(OH)D in Tibet during 2012 and 2013.

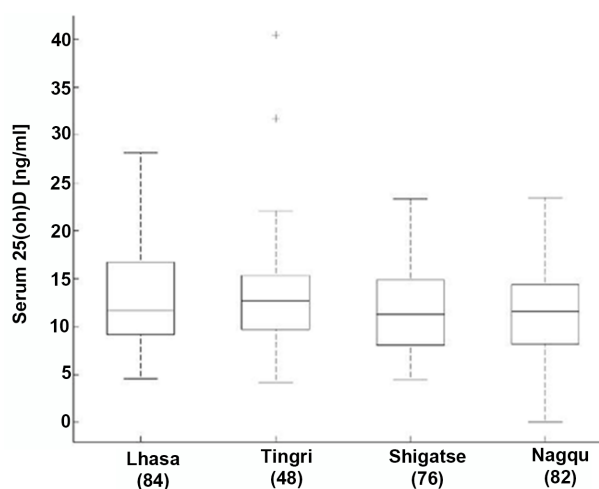


Figure 2. The levels of serum 25(OH)D in different regions in Tibet during 2012 and 2013.

Nagqu (11.5 ± 4.9 ng/mL), Shigatse (11.9 ± 4.7 ng/mL) and Tingri (13.4 ± 6.5 ng/mL) during 2012 and 2013. The levels of serum 25(OH)D in Lhasa, Nagqu, Shigatse were even lower than that of Tingri. The most reasonable explanation maybe is that Tingri lies at lower latitudes.

In agreement with our previous article [19], there is a great difference in levels

of serum 25(OH)D over different time. We found the level of serum 25(OH)D in the blood samples taken from Nicang village of Shigatse City changed during the years of 2007, 2008-2009 and 2012-2013 (the blood sample taken from residents of Bianxiong village where it is not far from Nicang village) (**Figure 3**).

Figure 3 shows that the levels of serum 25(OH)D in the residents of Nicang village of Shigatse City is declining. It decreased by 50% from an adequate level (25.42 ng/ml) to an inadequate level (12.25 ng/ml) in six years from 2007 to 2013.

A large number of research studies found that the serum 25(OH)D level decreased significantly in winter compared with summer, due to less outdoor activities in winter, which hinder the synthesis of vitamin D. This finding was also evident in our study (**Figure 4**, the average group is the mean value of the Lhasa, Shigatse, Tingri, Nagqu). Analysis from blood samples taken during 2012 and 2013 showed the serum 25(OH)D levels in winter (from 1st of December to 30th of April, 10.4 ± 4.5 ng/mL) decreased by 25 percent compared with summer (1st of May - 30th of October, 13.8 ± 5.1 ng/mL) in Tibet ($P < 0.001$). Moreover, the fact is demonstrated again by our research carried out in Nicang village during 2008 and 2009 (data not shown), in which the serum 25(OH)D level in winter decreased by 30 percent compared with summer.

The serum 25(OH)D level varies with ages. **Figure 5** showed content of serum 25(OH)D in all ages (over 18 years old). The serum 25(OH)D level of residents whose ages were between 20 and 40 years old was 20 percent higher than those over 40 years old. We believe this is related to less outdoor activities of middle-aged and older people.

We have tested the 25(OH)D level in different gender. The data of **Figure 6** (the average group is the mean value of the Lhasa, Shigatse, Tingri, Nagqu) demonstrated that in addition to Tingri, the level of serum 25(OH)D for male (12.8 ± 4.9 ng/mL) was higher than for female (11.9 ± 5.3 ng/mL, $P > 0.05$).

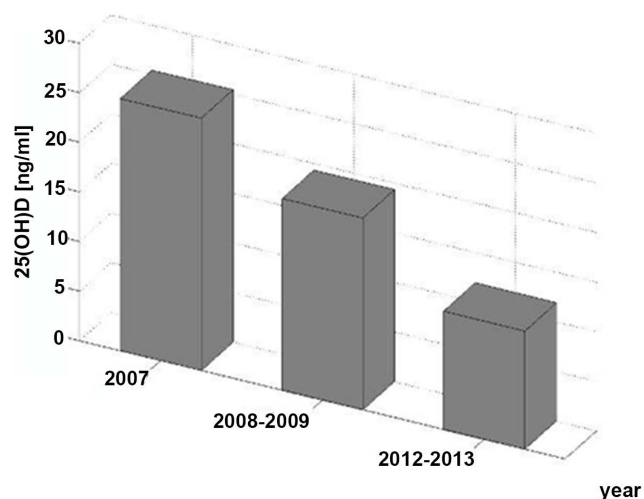


Figure 3. The levels of serum 25(OH)D, in different years, of the residents of Nicang village of Shigatse City, Tibet.

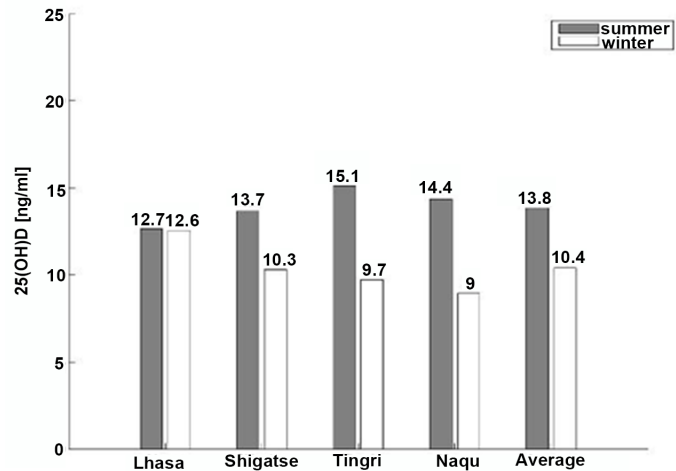


Figure 4. The serum 25(OH)D level in summer and winter in Tibet during 2008-2009.

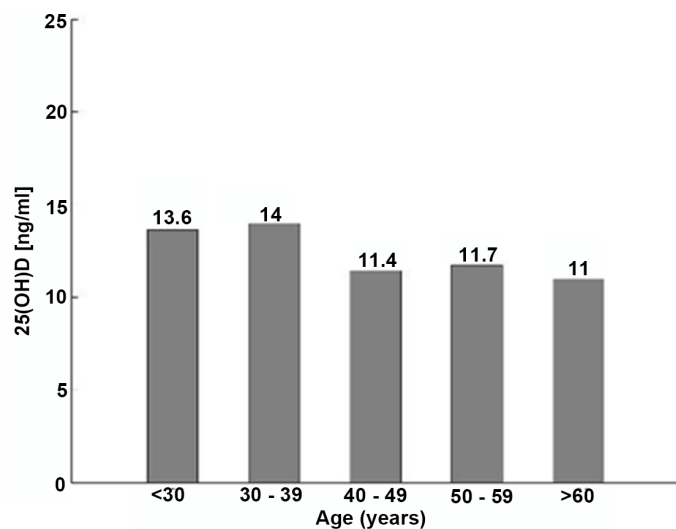


Figure 5. The serum 25(OH)D level in different ages in Tibet during 2012-2013.

We noticed most male volunteers in Tingri were over 50 years old when took blood examples, which perhaps is the reason for the unexpected data in Tingri.

Figure 7 showed the serum 25(OH)D level of people of different occupation in Lhasa and surrounding towns during 2012 and 2013. We found that the serum 25(OH)D level of all occupation were in deficiency range. Students and teachers serum 25(OH)D level (14.7 ± 4.9 ng/mL) is bit higher than farmers (11.1 ± 4.7 ng/mL) and herdsmen (14.4 ± 3.9 ng/mL).

4. Discussion

Around 90% of human Vitamin D synthesis is due to exposure of skin to sunlight, specifically to UV radiation. There is abundant solar UV available in Tibet. Ultraviolet intensity is up to level 5, the maximum ultraviolet radiation intensity

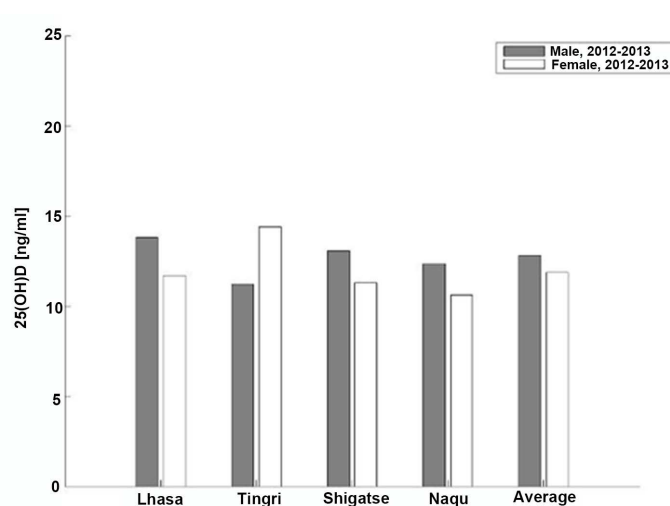


Figure 6. The serum 25(OH)D level in male and female during 2012 and 2013.

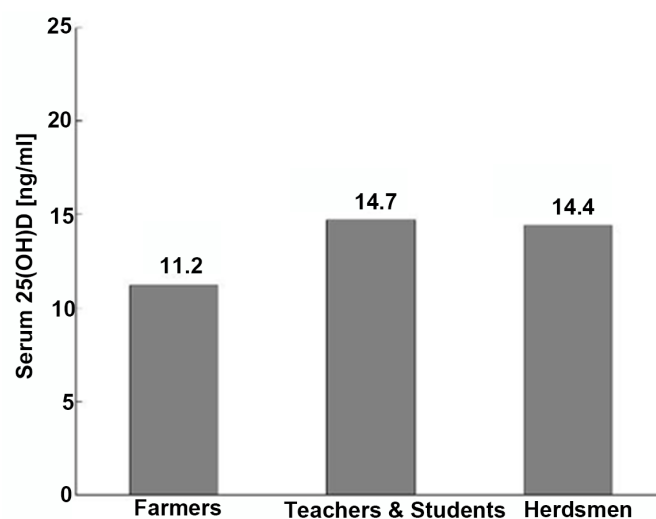


Figure 7. Average of 25(OH)D levels of different occupations during 2012 and 2013.

is 70 W/m^2 . Moreover, annual duration of sunshine is about 3000 hours, an average of 9 hours a day in Tibet. But to our surprise, the average of 25(OH)D value for residents in Tibet is not in the adequate range, on the contrary, it's in severely low level (Figure 1 and Figure 2). Moreover, it was found that increasing with the years from 2007 to 2013, the level of 25(OH)D in Tibetans was decreased obviously (Figure 3). There are several explanations for this phenomenon.

1) Diet and sun exposure is the only two ways to supplement vitamin D. Diet contributes between 10% and 20% to 25(OH)D levels [21]. Recommendations for human intake of vitamin D have been given in different countries. American Endocrine Society suggested each adult should intake 600 - 1000 IU (15 - 25 μg) vitamin D per day. It is necessary to have foods that contain high levels of vitamin D, such as fatty fish, liver, egg. However, in the present study, the food eaten

by volunteers (mainly are Tibetans) consists of samba, wheat, yak yoghurt, yak meat and moderate amounts of vegetables. All these food sources are poor in vitamin D.

2) The major natural source of the vitamin is synthesis in the skin through a chemical reaction that is dependent on sun exposure. Although the UV radiation is high in Tibet, traditionally residents avoid sun exposure, in particular women. In China, since women consider white skin as a symbol of beauty, their outdoor activities are reduced. More and more people use parasol at all times for avoiding sun exposure, almost no skin was exposed in the sunshine. Therefore, our data revealed that the serum 25(OH)D level was lower in female than in male (**Figure 6**) and decreases from 2007 to 2013 (**Figure 7**).

3) The low winter temperature in Tibet (typically, the winter daily averaged temperature in Tibet is around -5°C , even much lower in many places) leads to less outdoor activities, so the decrease of serum 25(OH)D level is expected.

4) High incidence of altitude diseases (such as cataracts, melanoma) caused by solar radiation makes people cautious to solar radiation, which can damage their health.

There is a general lack of common knowledge for Tibetans concerning the importance of solar radiation and vitamin D synthesis.

The human serum 25(OH)D level is influenced by their occupation and work environment (**Figure 7**). Unexpectedly it was found that the serum 25(OH)D level of teachers and students was slightly higher than farmers. It is no clear explanation for this finding. But, because farmers have dark skin, it may take much more time to synthesize same amount of vitamin D in dark-skinned people, so that dermal synthesis from sunlight is hindered.

5. Conclusion

The solar UV radiation in Tibet is highly intensive, which can bring both favorable and unfavorable factors to human health. The most important thing is to let people know: 1) how to expose self correctly to the sun; 2) how to realize the importance of vitamin D synthesis from sunlight; 3) how to have a rational diet with adequate amount of vitamin D. It is also important to continuously measure vitamin D level of Tibetans for further monitoring and improving the status of vitamin D and health in Tibet.

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