Asian Biomedicine Vol. 10 No. 6 December 2016; 595 - 601 DOI: 10.5372/1905-7415.1006.528

Brief communication (Original)

Vitamin D abnormalities in Thai patients with spinal cord injuries

Thanyaphon Khammeree[a], Ratana Vichiansiri[a], Kittisak Sawanyawisuth[b,c,d], Nuttaset Manimmanakorn[a]
[a]*Department of Rehabilitation Medicine, Khon Kaen University, Khon Kaen 40002, Thailand*
[b]*Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand*
[c]*Research Center for Back, Neck, Joint Pain and Human Performance (BNOJPH), Khon Kaen University, Khon Kaen 40002, Thailand*
[d]*Non-communicable Diseases Research Group, Khon Kaen University, Khon Kaen 40002, Thailand*

Background: Thai patients with spinal cord injury (SCI) are at risk of hypovitaminosis D. Data regarding prevalence and factors associated with low vitamin D levels in Asian patients with SCI are limited. Sunlight is considered adequate for vitamin D generation in tropical countries, but dietary factors may play a role in vitamin D deficiency in Thai patients with SCI.
Objectives: To determine the prevalence and factors associated with low vitamin D levels in Thai patients with SCI.
Methods: Were enrolled patients who were treated for SCI at Khon Kaen University Hospital between August 2013 and April 2014. Inclusion criteria were ≥18 years old and diagnosed as having an SCI of >3 months. Patients were excluded if they had bone cancer, stroke, cirrhosis, chronic kidney disease, were pregnant, or were taking medications that might affect vitamin D levels, including supplements. Vitamin D levels and histories of sunlight exposure, diet, and sunscreen use were studied.
Results: During the study period, 85 patients met inclusion criteria. Low vitamin D levels were found in 52 (61%). Two factors were found significantly associated with low vitamin D levels by multivariate logistic regression analysis: sunlight exposure of <2 times/week and low mushroom consumption. The adjusted odds ratios (95% confidence intervals) for these factors were 7.72 (1.09, 54.27) and 0.066 (0.009, 0.490) respectively.
Conclusions: The prevalence of low vitamin D levels in Thai patients with SCI was 61%. Factors associated with low vitamin D levels in SCI patients were the frequency of sunlight exposure and mushroom consumption.

Keywords: Risk factors, spinal cord injury, sunlight, vitamin D, 25(OH)D

Vitamin D (calcifediol, 25-hydroxycholecalciferol, or 25-hydroxyvitamin D (abbreviated as 25(OH)D)) deficiency decreases calcium and phosphorus absorption by the gastrointestinal tract, resulting in hypocalcemia. The main health effect of vitamin D deficiency is osteoporosis; particularly in the elderly. Elderly people with calcitriol levels less than 35 ng/mL have an increased risk of osteoporosis of the femoral neck [1]. Other conditions that may be related to vitamin D deficiency include falls, muscle strength, diabetes, or cardiovascular diseases [2].

In western countries, patients with spinal cord injuries (SCI) have a higher prevalence of vitamin D deficiency [3, 4]. Among veterans with SCIs, 32% had vitamin D deficiency [4]. The average vitamin D level of patients with SCI in Ohio state, USA, was 16.29 ng/mL [3]. There are limited data on vitamin D levels in patients with SCI in Asian countries. We studied the prevalence and factors associated with low vitamin D levels in Thai patients with SCI.

Correspondence to: Nuttaset Manimmanakorn, Department of Rehabilitation Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
E-mail: natman@kku.ac.th

Methods

Study population

The study protocol was approved by the ethics and research committees of Khon Kaen University (reference No. HE561232, record No. 4.2.05:28/2556). All patients with SCI who were treated at Khon Kaen University between August 2013 and April 2014 were screened for inclusion in the present study. The inclusion criteria were adult patients ≥18 years old

diagnosed with spinal cord injuries for >3 months. Patients were excluded if they had one of the following conditions; bone cancer, pregnancy, stroke, cirrhosis, chronic kidney disease, or were taking any of the following medications; parathyroid hormone, estrogen, progesterone, steroid, thyroid hormone, or vitamin D. Eligible patients provided written informed consent before participating. The anonymity of the data received was assured.

All patients who met the study criteria were interviewed and checked for vitamin D levels. One of the authors (TK) interviewed all patients regarding baseline characteristics including SCI data, history of dietary intake, history of sunlight exposure, and history of sunscreen use. Sources and frequency of vitamin D and calcium dietary consumption were evaluated for the previous six months. These were classified as regularly (5–7 days/week), frequently (1–4 days/week), sometimes (less than once a week), and never.

Serum vitamin D levels [25(OH)D] were measured by electrochemiluminescence immunoassay (ECLIA). Normal vitamin D levels were defined by [25(OH)D] >30 ng/mL, while the level of 20–30 ng/mL was defined as vitamin D insufficiency, and less than 20 ng/mL was defined as vitamin D severe deficiency. Both vitamin D insufficiency and severe deficiency were called vitamin D abnormalities.

Statistical analysis

The sample size calculation was based on the prevalence of vitamin D deficiency by Bauman et al. [4] The prevalence rate of 32% with a precision of the estimation of 0.1 suggested a sample size of 84.

Descriptive statistics were used to evaluate baseline characteristics, dietary factors, and vitamin D levels. Patients were divided into two groups according to vitamin D levels; normal or vitamin D abnormality (deficiency or insufficiency). Univariate and multivariate logistic regression analysis were applied to calculate the crude and adjusted odds ratios (ORs) of individual variables for vitamin D abnormalities. Analytical results are presented as adjusted ORs, and 95% confidence intervals (CIs).

Results

During the study period, 85 patients met the criteria for inclusion. Most patients were male, aged between 39–59 years, had a body mass index of 18.5–23.4 kg/m^2, a spinal cord injury caused by an accident classified as D according to the American Spinal Cord Injury Association, and a duration of spinal injury of <5 years as shown in **Table 1**.

Table 1. Baseline characteristics of all patients with spinal cord injuries

Factors	Number (n)	Percentage
Male sex	64	75
Age group (years)		
18–38	24	28
39–59	37	44
60–80	24	28
Body mass index, kg/m^2		
<18.5	11	13
18.5–23.4	41	48
≥23.5	33	39
Causes of spinal cord injuries		
Accident	44	52
Infection	11	13
Tumor	11	13
Degenerative disease	19	22
Characters of weakness		
Quadriplegia	30	35
Paraplegia	55	65
Level of weakness		
Cervical	28	33
Thoracic	29	34
Lumbar	25	29
Sacral	3	4

Table 1. (Con) Baseline characteristics of all patients with spinal cord injuries

Factors	Number (n)	Percentage
American Spinal Cord Injury Association (ASIA) classification		
A	19	22
B	15	18
C	14	17
D	37	44
Duration of weakness (years)		
<1	21	25
1–5	38	45
6–10	17	20
>10	9	11

Most patients had indoor lifestyles and did not use sunscreen. There were 38 patients who were exposed to sunlight less than 30 min/day and 62 patients who were exposed to sunlight >2 times/week. Eggs and milk were the two common components of their regular diet or were frequently consumed (**Table 2**).

Table 2. Vitamin D related factors of all patients with spinal cord injuries

Factors	Number (n)	Percentage
Daily activities		
Mostly outdoor	19	22
Functional status		
Unable to stand	31	37
Able to stand but unable to walk	21	25
Walkable	33	39
Exposure to sunlight		
≥30 min/day	47	55
Frequency of sunlight exposure		
≥2 times/week	62	73
History of sunscreen use	19	22
Area of sunscreen use		
Face only	6	32
Face and body	13	68
SPF of sunscreen		
>50	1	5
30–50	1	5
<30	2	11
Do not know	15	79
Dietary history		
Fish oil 1 tablespoon/day		
Regularly	4	5
Frequently	1	1
Sometimes	6	7
Never	74	87
Salmon		
Regularly	0	0
Frequently	1	1
Sometimes	4	5
Never	80	94

Table 2. (Con) Vitamin D related factors of all patients with spinal cord injuries

Factors	Number (n)	Percentage
Canned fish		
Regularly	0	0
Frequently	9	11
Sometimes	40	47
Never	36	42
Liver/meat		
Regularly	5	6
Frequently	14	17
Sometimes	36	42
Never	30	35
One egg		
Regularly	24	28
Frequently	49	58
Sometimes	8	9
Never	4	5
Foods containing cooked or boiled mushrooms		
Regularly	4	5
Frequently	20	24
Sometimes	44	52
Never	17	20
Milk/soymilk		
Regularly	35	41
Frequently	11	13
Sometimes	23	27
Never	16	19
Yogurt one cup		
Regularly	2	2
Frequently	7	8
Sometimes	18	21
Never	58	68
Other fish		
Regularly	39	46
Frequently	9	11
Sometimes	24	28
Never	13	15

Vitamin D abnormalities were found in 52 patients. They were categorized as having vitamin D deficiency (32%) and insufficiency (29%) as shown in **Table 3**. Various factors were tested for vitamin D abnormality by logistic regression analysis (**Table 4**). Only 2 were significantly associated with vitamin D abnormality by both univariate and multivariate logistic regression analysis; sunlight exposure of <2 times/week and low mushroom consumption. The adjusted odds ratios (95% confidence intervals) of these factors were 7.72 (1.09, 54.27) and 0.066 (0.009, 0.490) respectively.

Table 3. Vitamin D status of all patients with spinal cord injuries

Status	Number	Percentage	95% Confidence interval
Vitamin D deficiency	27	32	21.90, 41.70
Vitamin D insufficiency	25	29	19.71, 39.09
Normal	33	39	28.44, 49.16

Table 4. Factors associated with abnormal vitamin D levels in patients with spinal cord injury by logistic regression analysis

Factors	Crude odds ratio (95% confidence interval)
Male sex	0.73 (0.26, 2.06)
Age >48 years	0.63 (0.26, 1.52)
Body mass index, kg/m^2	
<18	3.89 (0.75, 20.3)
≥23.5	1.51 (0.59, 3.86)
Causes	
Accident	1.94 (0.65, 5.18)
Infection	1.99 (0.44, 8.92)
Tumor	2.96 (0.60, 14.7)
Level of SCI	
Cervical	3.60 (0.29, 44.8)
Thoracic	4.44 (0.36, 55.6)
Lumbar	2.17 (0.17, 27.1)
American Spinal Cord Injury Association classification	
A	2.13 (0.64, 7.16)
B	1.14 (0.34, 3.87)
C	1.02 (0.29, 5.52)
Duration of SCI (years)	
<1	0.38 (0.06, 2.29)
1–5	0.39 (0.07, 2.15)
6–10	0.52 (0.08, 3.36)
Activities: mostly indoor	0.64 (0.23, 1.78)
Sunlight exposure <30 min/day	2.16 (0.87, 5.34)
Sunlight exposure <2 times/wk	**2.97 (0.98, 9.00)***
Sunscreen use	1.50 (0.51, 4.44)
Fish oil (sometimes or never)	1.50 (0.17, 6.67)
Cooked or boiled mushroom (sometimes or never)	**0.22 (0.07, 0.72)***
Milk (sometimes or never)	1.26 (0.52, 3.03)
Yogurt (sometimes or never)	0.42 (0.08, 2.13)

*Bold highlighting indicates significant association by univariate logistic regression

Discussion

The prevalence of low vitamin D levels in our patients was 61%, which was higher than previously reported prevalence in the elderly in Thailand (38.7% and 48%) [5, 6]. Consistent with previous reports, patients with SCI had significantly lower vitamin D levels than control subjects [4]. The present study suggested that hypovitaminosis D may be more prevalent in patients with SCI than in elderly control subjects.

Compared with western countries, the prevalence of vitamin D deficiency in Thai patients with SCI was higher than in patients with SCI in the US or Canada (32% and 39%) despite higher levels of sunlight in Thailand [4, 7]. These findings may be a consequence of dietary and genetic factors. Thai patients with SCI tended to consume low amounts of vitamin D containing products (**Table 2**). Vitamin D binding protein gene polymorphism may also be a reason for the low vitamin D levels [8].

In Thai patients with SCI, 2 independent factors were associated with having low vitamin D levels: the frequency of sunlight exposure and mushroom consumption. We found that the duration of sunlight exposure was not significantly associated with vitamin D levels. By contrast, the frequency of sunlight exposure was an independent factor with an adjusted OR of 7.72. These data implied that people with SCI should be exposed to sunlight more frequently, particularly during the day from 10:00 to 15:00 [9].

Consumption of mushrooms, which contain vitamin D, was an important dietary factor for patients with SCI who have low vitamin D levels, while consumption of other vitamin D containing foods was not

significantly associated with low vitamin D levels (**Table 4**). Surprisingly, eating less mushrooms was less likely to cause vitamin D abnormalities with adjusted OR of 0.066. Mushrooms have a high content of vitamin D when raw and exposed to ultraviolet-B light (UV-B) in nature [10-12]. It was surprising that consumption of mushrooms frequently or daily by Thai patients with SCI, increased risk of lower vitamin D levels. Patients were asked if they frequently consumed mushroom soup or fried mushrooms. In the northeastern part of Thailand where Khon Kaen province is located, people usually eat mushrooms unexposed to UV-B cooked or fried. Boiling or frying have been shown to cause substantial loss of vitamin D in mushrooms [10, 11]. Cooked mushrooms may also have lower content than uncooked mushrooms [10]. Furthermore, patients who consumed more mushrooms may consume less of other food that contains vitamin D. The most important source of vitamin D is sunlight; which is confirmed by the present study.

The present study addresses more risk factors for low vitamin D levels than a study conducted in Canada. Hummel et al. [7] found that the winter season, age, paraplegia, calcium supplements, failure to take vitamin D supplements, and lack of bisphosphonate treatment were significantly associated with low vitamin D levels. These differences can be explained by lower exposure to sunlight and dietary habits. Thai people do not generally consume vitamin supplements.

There are some limitations of the present study. The method used to detect vitamin D levels was not the criterion standard. High performance liquid chromatography analysis may find lower levels of vitamin D. The vitamin D values found in our patients by ECLIA may be higher than true values. Another limitation is that the history of dietary consumption may not have reliable validity if the patients do not have regular eating habits.

In conclusion, the prevalence of vitamin D abnormalities in Thai patients with SCI is at least 61%. Factors associated with low vitamin levels in Thai patients with SCI were the frequency of sunlight exposure and mushroom consumption. Many people in tropical countries try to avoid sunlight. Nevertheless, patients with SCI in tropical countries should be encouraged to get adequate sunlight exposure and have rational dietary habits.

Conflict of interest statement

The authors declare that there is no conflict of interest in this research.

Acknowledgments

The authors thank Faculty of Medicine, Khon Kaen University for an Invitation Research Grant and the Thailand Research Fund (TRF) for their kind support (IRG 5780016). This research was also funded in part by grants from the Higher Education Research Promotion National Research University Project of Thailand, Office of the Higher Education Commission through the Health Cluster (SHeP-GMS), Thailand; the Faculty of Medicine, Khon Kaen University grant number TR57201; and the TRF Senior Research Scholar Grant, Thailand Research Fund grant number RTA5880001.

References

1. Zehnder Y, Lüthi M, Michel D, Knecht H, Perrelet R, Neto I, et al. Long-term changes in bone metabolism, bone mineral density, quantitative ultrasound parameters, and fracture incidence after spinal cord injury. Osteoporos Int. 2004; 15:180-9.
2. Holick MF. Vitamin D deficiency. N Eng J Med. 2007; 357:266-81.
3. Nemunaitis GA, Mejia M, Nagy JA, Johnson T, Chae J, Roach MJ. A descriptive study on vitamin D levels in individuals with spinal cord injury in an acute inpatient rehabilitation setting. PM R. 2010; 2:202-8.
4. Bauman WA, Zhong YG, Schwartz E. Vitamin D deficiency in veterans with chronic spinal cord injury. Metabolism. 1995; 44:1612-6.
5. Kruavit A, Chailurkit LO, Thakkinstian A, Sriphrapradang C, Rajatanavin R. Prevalence of vitamin D insufficiency and low bone mineral density in elderly Thai nursing home residents. BMC Geriatr. 2012; 12:49. doi: 10.1186/1471-2318-12-49.
6. Soontrapa S, Soontrapa S, Chaikitpinyo S. Prevalence of vitamin D insufficiency among the elderly males living in the urban areas of Khon Kaen Province in the northeast of Thailand. J Med Assoc Thai. 2011; 94:S59-62.
7. Hummel K, Craven BC, Giangregorio L. Serum 25(OH)D, PTH and correlates of suboptimal 25(OH)D levels in persons with chronic spinal cord injury. Spinal Cord. 2012; 50:812-6.
8. Thongthai P, Chailurkit LO, Chanprasertyothin S, Nimitphong H, Sritara P, Aekplakorn W, et al. Vitamin D binding protein gene polymorphism as a

risk factor for vitamin D deficiency in Thais. Endocr Pract. 2015: 21:221-5.
9. Stalgis-Bilinski KL, Boyages J, Salisbury EL, Dunstan CR, Henderson SI, Talbot PL. Daylight: balancing vitamin D requirements with sensible sun exposure. Med J Aust. 2011; 194:345-8.
10. Mehrotra A, Calvo MS, Beelman RB, Levy E, Siuty J, Kalaras MD, et al. Bioavailability of vitamin D2 from enriched mushrooms in prediabetic adults: a randomized controlled trial. Eur J Clin Nutr. 2014; 68: 1154-60.
11. Jakobsen J, Knuthsen P. Stability of vitamin D in foodstuffs during cooking. Food Chem. 2014; 148: 170-5.
12. Ko JA, Lee BH, Lee JS, Park HJ. Effect of UV-B exposure on the concentration of vitamin D2 in sliced shiitake mushroom (*Lentinus edodes*) and white button mushroom (*Agaricus bisporus*). J Agric Food Chem. 2008; 56:3671-4.