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Original Article

Vitamin D deficiency in student athletes in Thailand

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Abstract

This study aimed to evaluate the prevalence of hypovitaminosis D and the possible risk factors in Thai athletes. This cross-sectional study was conducted in 96 student athletes (73 males, 23 females) at the Institute of Physical Education Udonthani Thailand. Vitamin D (25(OH)D) deficiency (<20 ng/mL) or insufficiency (20-30 ng/mL) was determined using a standard blood test. The mean±SD age was 20.8±1.4 years. The prevalence of hypovitaminosis D was 42.7% (8.3% for vitamin D deficiency, 34.4% for vitamin D insufficiency). Factors related to hypovitaminosis D included being a female (OR=2.7, 95% CI 1.0-7.0, P=0.04), and sun exposure of 30 min or less per day (OR=3.1, 95% CI 1.2-8.0, P=0.01). However, types of sport, sunscreen application, and consumption of high vitamin D foods were not significantly related to hypovitaminosis D prevalence. The relatively high prevalence of hypovitaminosis D in student athletes suggests these sport athletes (particularly the females) should consider increasing their exposure to vitamin D producing mechanisms.

Keywords: vitamin D, deficiency, insufficiency, athlete, associated factors

1. Introduction

Vitamin D has an important role in multi-organ functions particularly on the musculoskeletal system where it influences bone growth and remodeling, helps regulate gene expression and protein synthesis in muscle, and assists immune function (Ogan & Pritchett, 2013). The majority of vitamin D is synthesized in the skin through the effects of ultraviolet radiation (sunlight), on the pre-cursor substance (7-dehydrocholesterol), while the remaining vitamin D is sourced through the diet (Holick, 2007; Nair & Maseeh, 2012). The active form of vitamin D (1,25-dihydroxyvitamin D_3 or 25(OH)D), which has hydroxyl groups added initially in the liver and then in the kidney, acts more like a hormone than a vitamin.

Hypovitaminosis D (low vitamin D levels) is commonly found in different populations such as children, postmenopausal women, and the elderly (Chailurkit, Kruavit, & Rajatanavin, 2011; Gaugris *et al.*, 2005; Huh & Gordon, 2008). Hypovitaminosis D also frequently occurs in athletes and has a number of detrimental effects including bone loss and increased risk of stress fractures, decreased muscle size, muscle mass and subsequent sport performance, and lowered immunity thereby increasing the risk of infection during the sport season (Ogan & Pritchett, 2013). Hypovitaminosis D is related to lifestyle factors such as a lack of sun exposure, overuse of sunscreen lotion or too much sun protection

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(Constantini, Arieli, Chodick, & Dubnov-Raz, 2010; Holick & Chen, 2008; Lehtonen-Veromaa *et al.*, 1999). In addition, a lack of dietary vitamin D intake, abnormal vitamin D absorption, diminished vitamin D synthesis in the liver and kidney and some medications can reduce the vitamin D levels (Holick & Chen, 2008).

The prevalence of hypovitaminosis D in athletes has been observed in a number of countries including USA (39 %), Australia (34%), Spain and France (32%), UK and Ireland (70%), and the Middle East (84%) (Farrokhyar *et al.*, 2015). In Thailand, the prevalence of hypovitaminosis D has been reported in the general population at 45.2% (Chailurkit, Aekplakorn, & Ongphiphadhanakul, 2011) and various sub-groups such as elderly women (32-39%) (Chailurkit *et al.*, 2011; Kruavit, Chailurkit, Thakkinstian, Sriphrapradang, & Rajatanavin, 2012) and spinal cord injury patients (61%) (Khammeree, Vichiansiri, Sawanyawisuth, & Manimma nakorn, 2016). However, the prevalence of hypovitaminosis D in athletes has not been reported. Such information is important as vitamin D has a vital role to play in the potential performance and health of such athletes. Therefore, this study aimed to evaluate the prevalence of, and lifestyle factors related to, hypovitaminosis D in Thai athletes.

2. Materials and Methods

2.1 Study design and participants

This cross-sectional descriptive study was conducted on student athletes from the Tertiary Institute of Physical Education, Udonthani. These athletes were ≥18 years of age and completed exercise training for at least 3 h per day, 3 times per week for 1 year or more. Athletes with chronic diseases, such as renal failure, chronic kidney failure, chronic lung disease, gastrointestinal disease, uncontrolled psychiatric and neurological diseases, and those who had bone cancer, were pregnant or taking medication including parathyroid hormone, estrogen, progesterone, steroids, thyroid hormone, and vitamin D, were excluded. This study was carried out in accordance with the recommendations of the Khon Kaen University Human Research Ethics guidelines. All participants gave their written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Human Research Ethics Committee, Khon Kaen University (HE 571422).

The data collection was conducted in March 2015 at Udonthani Province in the northeastern part of Thailand. The athletes were interviewed and the researchers recorded the details of their demographic data and hypovitaminosis D lifestyle-related factors including characteristics of sun exposure, food consumption, musculo-skeletal injury, and upper respiratory tract infection over the previous 3 months. Athletes were asked to rate their consumption habits of vitamin D containing foods as (1) always consume food, e.g., 5-7 times/week, (2) frequently consume food (1-4 times/ week), (3) rarely consume food (less than 1 time/week), and (4) never consume food (no consumption). On the same day the anthropometric data of the participants, such as age, height, and weight, were recorded. Age was calculated from the date of birth to the date of the recording. Height without shoes was measured to the nearest 0.1 cm by a wall-mounted stadiometer. Weight, without shoes and with minimal clothing, was measured to the nearest 0.1 kg on an electronic scale.

A 5-mL blood sample was taken from the brachial vein at the cubital fossa by certified nurses around 8:00 AM after an overnight fast. Participants were rested (seated) for at least 10 min prior to the blood being drawn. The sampled blood was deposited in a clotting blood gel tube (Vacuette@, Greiner Bio-one GmbH, Kremsmünster, Austria), and stored at 2-8 °C until it was sent to Srinagarind Hospital, Khon Kaen University Blood Laboratory within 2 h of being drawn. The measurement of 25(OH)D concentration in the serum was analyzed via an electrochemiluminescense immunoassay kit (ECLIA, Roche Diagnostics International Ltd, Switzerland) using a Cobas® 6000 analyzer (Roche Diagnostics Corp., Indianapolis, IN, USA). The sum of serum $25(OH)D_2$ and $25(OH)D_3$ was used to determine total serum 25(OH)D. The inter-assay and intra-assay coefficients of variation of total serum 25(OH)D were 6.5% and 11.5% respectively.

This study defined the severity of hypovitaminosis D according to level of serum 25(OH)D into two groups: vitamin D deficiency (serum 25(OH)D level <20 ng/mL) and vitamin D insufficiency (serum 25(OH)D level 20-30 ng/mL) (Holick, 2007).

2.2 Statistical analysis

The prevalence of hypovitaminosis D and associated factors were calculated and analyzed using STATA version 10 program. The data were presented as number, percentage, mean and standard deviation. To analyze the relationship between vitamin D and the associated factors, univariate analysis was completed using the Chi-Square test and a multivariate analysis was performed by multiple logistical regression. The degree of association between vitamin D and the associated factors is shown as an odds ratio and 95% confidence interval with the P value also given.

3. Results

3.1 Demographic data

This study included 96 participants, 73 males (76.0%) and 23 females (24.0%). The mean body mass index and mean age were 22.0±3.4 kg/m^2 and 20.8±1.4 years, respectively, and all of them had reasonably dark skin. No one used vitamin D supplement or multivitamin. Most of participants normally trained outdoors (57.3%), were exposed to the sun more than two times per week (86.5%) and for more than 30 min per day (63.5%). More than half (57.3%) of the participants normally applied sunscreen lotion when training outdoors (45.5% applied it to the face and 54.6% to the face and body). Approximately 17.7% of the total population surveyed suffered a musculo-skeletal injury over the 3 months prior to the survey and most of the injuries were related to muscle strains or tears (88.2%). About 22.9% of the total participants had upper respiratory tract infections during the previous 3 months (Table 1).

The majority of participants frequently, i.e. 1-4 times per week, consumed eggs, cow’s milk or soybean milk, rarely, i.e. <1 time per week, consumed salmon, canned fish, liver, meat, mushrooms, yogurt or fresh fish and never consumed cod-liver oil (Table 2).

Table 1. Characteristics and lifestyle-related factors (previous 3 months) of study participants.

Participant characteristics and lifestyle factors	Mean±SD/n (%)
Age (year)	20.8±1.4
Weight (kg)	63.6±12.5
Height (cm)	169.4±8.5
Body mass index (kg/m^2)	22.0±3.4
Male	73 (76.0)
Female	23 (24.0)
Only train indoors	30 (31.3)
Only train outdoors	55 (57.3)
Train both indoors and outdoors	11 (11.5)
Weekly sun exposure	
<2 times per week	13 (13.5)
≥2 times per week	83 (86.5)
Sun exposure time per day	
>30 minutes	61 (63.5)
≤30 minutes	35 (36.5)
Regularly use sunscreen	55 (57.3)
No sunscreen	41 (42.7)
Area sunscreen applied	
Face	25 (45.5)
Face and body	30 (54.5)
SPF of sunscreen used	
>50	7 (12.7)
30-50	9 (16.4)
15-30	15 (27.3)
unknown	24 (43.6)
Recent musculo-skeletal injury	
Yes	17 (17.71)
No	79 (82.29)
Type of musculo-skeletal injury	
Fracture	2 (11.8)
Muscle or tendon tear	5 (29.4)
Muscle strain or tendinitis	10 (58.8)
Body area of musculoskeletal injury	
Upper extremities	3 (17.7)
Lower extremities	12 (70.6)
Trunk (included back)	2 (11.8)
Recent URI	
Yes	22 (22.9)
No	74 (77.1)

Data are presented as mean±SD or n (%), SPF = sun protective factor, URI = upper respiratory tract infection

3.2 Vitamin D level

The mean serum 25(OH)D level of the young athletes was 31.9±8.3 ng/mL. The histogram of vitamin D levels is presented in Figure 1. The prevalence of hypo-vitaminosis D was 42.7% (8.3% for vitamin D deficiency (25(OH)D <20 ng/mL) and 34.4% for vitamin D insufficiency (25(OH)D [20-30 ng/mL]).

3.3 Hypovitaminosis D related factors

A univariate analysis of the dietary consumption and lifestyle factors associated with hypovitaminosis D is presented in Tables 3 and 4. The significant factors were being female and having only 30 min or less of sun exposure per day, while the consumption of high vitamin D foods such as cod-liver oil, salmon, canned fish, liver, meat, eggs, mushrooms, cow's milk, soybean milk, yogurt, and fresh fish were not related to hypovitaminosis D. The multiple logistic regression analysis showed that females were 2.7 times more likely to suffer hypovitaminosis D compared to males (95% CI 1.0-7.4, P=0.04), and athletes that only accumulated 30 min or less of sun exposure per day were 3.1 times more likely to suffer hypovitaminosis D than those athletes that accumulated over 30 min of sun exposure per day (95% CI 1.0-7.0, P = 0.01).

Table 2. Dietary consumption habits (previous 3 months) of study participants.

Vitamin D containing food	n (%)
Cod-liver oil 15 mL	
Always	0
Frequently	2 (2.1)
Rarely	44 (45.8)
Never	50 (52.8)
Canned fish	
Always	6 (6.3)
Frequently	20 (20.8)
Rarely	62 (64.6)
Never	8 (8.3)
Liver/Meat	
Always	8 (8.3)
Frequently	40 (41.7)
Rarely	45 (46.9)
Never	3 (3.1)
Eggs	
Always	38 (39.6)
Frequently	44 (45.8)
Rarely	14 (14.6)
Never	0
Mushrooms	
Always	5 (5.2)
Frequently	28 (29.2)
Rarely	63 (65.6)
Dry sprats	
Always	12 (12.5)
Frequently	41 (42.7)
Rarely	43 (44.8)

Data are presented as n (%). Always, 5-7 times/week, Frequently, 1-4 times/week, Rarely, less than 1 time/week, Never, no consumption over the last 3 months.

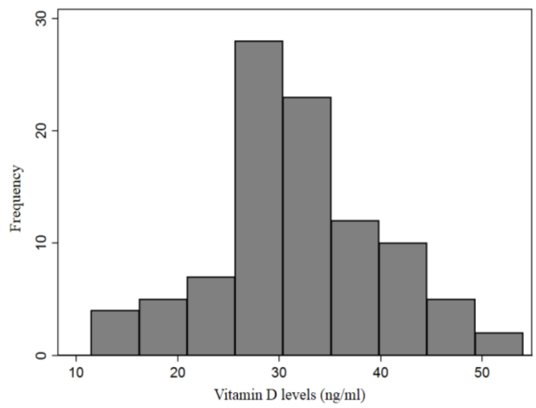

Figure 1. Histogram of vitamin D levels.

Table 3. Relationship between dietary consumption factors (previoust 3 months) and plasma Vitamin D levels.

	Hypovitaminosis D	Normal Vitamin D	OR (95% CI)	P value
Cod-liver oil 15 mL				0.46
Never	19 (46.3)	31 (56.4)		
Rarely	20 (48.8)	24 (43.6)	1.4 (0.6-3.1)	
Frequently	2 (4.9)	0 (0.0)		
Canned fish				0.93
Never	4 (9.8)	4 (7.3)		
Rarely	27 (65.9)	35 (63.6)	0.8 (0.2-3.4)	
Frequently	8 (19.5)	12 (21.8)	0.7 (0.1-3.5)	
Always	2 (4.9)	4 (7.3)	0.5 (0.1-4.5)	
Liver/Meat				0.84
Never	1 (2.4)	2 (3.6)		
Rarely	22 (53.7)	23 (41.8)	1.9 (0.2-22.6)	
Frequently	18 (43.9)	22 (40.0)	1.6 (0.1-19.5)	
Always	0 (0.0)	8 (14.6)		
Egg				0.44
Rarely	4 (9.8)	10 (18.2)		
Frequently	21 (51.2)	23 (41.8)	2.3 (0.6-8.4)	
Always	16 (39.0)	22 (40.0)	1.8 (0.5-6.8)	
Mushrooms				0.53
Rarely	28 (68.3)	35 (63.6)		
Frequency	10 (24.4)	18 (32.7)	0.7 (0.3-1.7)	
Always	3 (7.3)	2 (3.6)	1.9 (0.3-12.0)	
Dry sprats				0.39
Rarely	19 (46.3)	24 (43.6)		
Frequency	19 (46.3)	22 (40.0)	1.1 (0.5-2.6)	
Always	3 (7.3)	9 (16.4)	0.4 (0.1-1.8)	

Data are presented as n (%). Always, 5-7 times/week, Frequently, 1-4 times/week, Rarely, less than 1 time/week, Never, no consumption over the last 3 months.

Table 4. Relationship between lifestyle factors (previous 3 months) and plasma Vitamin D levels.

	Hypovitaminosis D	Normal Vitamin D	OR (95% CI)	P value
Gender				0.04*
Male	27 (65.9)	46 (83.6)		
Female	14 (34.1)	9 (16.4)	2.7 (1.0-6.9)	
Training				0.22
Only train indoors	14 (34.2)	16 (29.1)		
Only train outdoors	20 (48.8)	35 (63.6)	0.7 (0.3-1.6)	
Train both indoors and outdoors	7 (17.1)	4 (7.3)	2 (0.5-8.3)	
Weekly sun exposure				0.74
≥2 times per week	36 (87.8)	47 (85.5)		
<2 times per week	5 (12.2)	8 (14.6)	0.8 (0.3-2.7)	
Sun exposure time per day				0.01*
>30 minutes	20 (48.8)	41 (74.5)		
≤30 minutes	21 (51.2)	14 (25.5)	3.1 (1.2-8.0)	
Sunscreen				0.28
Regularly use sunscreen	26 (63.4)	29 (52.7)		
No sunscreen lotion	15 (36.6)	26 (47.3)	0.6 (0.3-1.5)	
Area sunscreen applied				0.65
Face	11 (42.3)	14 (42.3)		
Face and body	15 (57.7)	15 (51.7)	1.3 (0.4-3.7)	
SPF of sunscreen used				0.30
>50	2 (7.7)	5 (17.2)		
30-50	4 (15.4)	5 (17.2)	2 (0.2-16.4)	
15-30	10 (38.5)	5 (17.2)	5 (0.7-35.5)	
Unknown	10 (38.5)	14 (48.3)	1.8 (0.3-11.1)	
Recent musculo-skeletal injury				0.14
Yes	10 (24.4)	7 (12.7)		
No	31 (75.6)	48 (87.3)	0.5(0.2-1.3)	
Recent URI				0.43
Yes	11 (26.8)	11 (20.0)		
No	30 (73.2)	44 (80.0)	0.7 (0.3-1.8)	

Data are presented as n (%), SPF = sun protective factor, URI = upper respiratory tract infection, *significant at $P<0.05$

4. Discussion

The average vitamin D level of participants was 31.9±8.3 ng/mL, and the prevalence of vitamin D deficiency in student athletes at the Institute of Physical Education Udonthani was 8.3% while vitamin D insufficiency was 34.4% resulting in an overall prevalence of hypovitaminosis D in Thai athletes of 42.4% which was higher than athletes in the USA, Spain, and France, but lower than athletes in the UK, Ireland or Middle East (Farrokhyar *et al.*, 2015). The difference in the prevalence of hypovitaminosis D in various countries depends on a number of factors including ethnicity, climate, landscape, season, and diet (Mithal *et al.*, 2009).

The prevalence of hypovitaminosis D in the Thai athletes in this study was similar to the Thai general population (45.2%). However, this study was conducted in the northeastern part of Thailand which has a prevalence of hypovitaminosis D much lower than the general Thailand population at 32.9±9.7 ng/mL (Chailurkit, Aekplakorn, & Ongphiphadhanakul, 2011). Since our athletes had significantly higher levels of hypovitaminosis D than the general population of the area (Northeast) we would suggest these athletes consider ways to increase their vitamin D sources.

This study found the factors associated with vitamin D level were sex and sun exposure time. Female athletes were 2.7 times more likely to have hypovitaminosis D than male athletes, which corresponded to national data which indicated overall that females were more likely than males to suffer hypovitaminosis D (Chailurkit, Aekplakorn, & Ongphiphad hanakul, 2011; Hashemipour *et al.,* 2004). Thai females are likely to wear more clothing and avoid expose to the sunlight than males. In addition, less sun exposure time increased the risk of hypovitaminosis D by 3.6 times (95% CI 1.0-12.0). Holick (2004) suggested that sunlight exposure to the arms and legs or the hands, arms, and face for 5-10 min 2 or 3 times per week combined with sufficient vitamin D intake would be adequate to prevent vitamin D deficiency (Holick, 2004). However, Nair and Maseeh (2012) stated that people with dark skin need at least three to five times longer sun exposure than people with pale skin (Nair & Maseeh, 2012). This study, which was conducted in Thai athletes who have a moderate to dark brown skin tone, suggests that students should receive at least 30 min of sunlight exposure per day.

Other factors that we measured, such as the frequency of sun exposure (≥2 times per week), being involved in indoor or outdoor sport, and the use of sun screen, did not have large effects on the Thai athlete hypovitaminosis D prevalence in this setting. Consuming food rich in vitamin D also was not significantly associated with the prevalence of hypovitaminosis D. In addition, we did not find any increased incidence of musculoskeletal injury or respiratory tract infections in the hypovitaminosis D group compared to the normal vitamin D group. However, this study was conducted in the summer when there was little athletic competition. Further research needs to investigate whether the lack of vitamin D during heavy competition phases of the season may result in increased prevalence of musculoskeletal injury or respiratory tract infection.

This study has some limitations. The participants were student athletes who did not represent all Thai athletes. Also, the study was conducted in the summer when the athletes were in their non-competitive training phase. Furthermore, the number of participants may be too small to detect all related factors.

5. Conclusions

This study showed that the prevalence of hypovitaminosis D in student athletes in the Institute of Physical Education Udonthani was 42.7% (8.3% for vitamin D deficiency and 34.4% for vitamin D insufficiency). Factors positively related to hypovitaminosis D prevalence were being female and having 30 min or less of sun exposure per day.

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