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Original Article

Association Between Serum Vitamin D Levels, Skin Color and Estimated Sunlight Exposure Time in Young Adults Residing in Yangon Region

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ABSTRACT

Background and Aim: People living in Myanmar are exposed to adequate sunlight throughout the year. Therefore, residents of Yangon, one of Myanmar's cities, are assumed to have sufficient vitamin D levels from sunlight. While many studies suggested that individuals with fair skin tend to produce more vitamin D than those with darker skin, some studies found lower vitamin D levels in fair-skinned individuals compared to their darker-skinned counterparts. Since young adults are more likely to engage in outdoor activities, they are expected to have more sunlight exposure and higher vitamin D levels. This raises an interesting question whether young adults of different skin colors exhibit varying serum vitamin D levels. Thus, the present study aimed to find out vitamin D status and its association with skin color and estimated sunlight exposure time in young adults. **Materials and Methods:** This study was carried out in 143 young adults aged 21-39 years. Serum vitamin D level was measured by enzyme-linked immunosorbent assay method and skin color by skin tone analyzer. Sunlight exposure time was estimated by questionnaires. **Results:** Among 143 subjects, 67.8% were vitamin D sufficient (≥32 ng/mL), 28.7% were vitamin D insufficient (20-31 ng/mL) and 3.5% were deficient (<20 ng/mL). Gender difference in serum 25(OH)D level was observed ($p<0.001$). Statistically significant association was observed between vitamin D status and estimated sunlight exposure time groups ($p<0.001$) and skin color groups ($p<0.05$). **Conclusion:** It can be assumed that both estimated sunlight exposure time and skin color are contributing factors for determining serum vitamin D levels.

Keywords: Estimated sunlight exposure time, Skin color, Vitamin D.

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INTRODUCTION

Vitamin D, a fat-soluble vitamin, is mainly made in the skin from 7-dehydrocholesterol under the influence of ultraviolet B (wavelength 290-315 nm) in the sunlight and it is found in the body as vitamin D_3 (cholecalciferol). The major role of vitamin D in the body is to maintain calcium and phosphate homeostasis and bone health.[1] In addition, recent studies have shown that vitamin D also plays an essential role in non-skeletal human health by inhibiting carcinogenic cell proliferation, inhibiting inflammatory cytokine production, promotion of innate immunity[2] and mediating synthesis of neurotransmitters and regulating its functions.[3]

Vitamin D deficiency is now highly prevalent worldwide. It has been estimated that one billion people worldwide have vitamin D deficiency or insufficiency. The 25-hydroxyvitamin D [25(OH) D], the major circulating form of vitamin D, is the best indicator of vitamin D status.[1] It is recommended that adults aged 19-50 years require at least 600 IU/day of vitamin D to maximize bone health and muscle function.[4] Vitamin D deficiency is defined when serum 25(OH)D concentration is <20 ng/mL (<50 nmol/L); vitamin D insufficiency is defined when serum 25(OH) D is 20-<32 ng/mL (50-<80 nmol/L) and vitamin D sufficiency is defined when serum 25(OH)D is ≥32 ng/mL (≥80 nmol/L).[5]

The previous Myanmar studies done in various age groups showed vitamin D insufficiency and deficiency in prepubertal school children aged 8-10 years,[6] indoor and outdoor adolescent athletes,[7] elderly women[8] and postmenopausal women.[9] As sunlight exposure is one of the major sources of vitamin D synthesis, young adults are expected to get more sunlight exposure time and thus more serum vitamin D levels as they may have more outdoor activities than children and elderly who spend most of their time staying indoors. While many studies suggested that individuals with fair skin tend to produce more vitamin D than those with darker skin,[10] some studies found lower vitamin D levels in fair-skinned individuals compared to their darker-skinned counterparts.[11] Normal human skin color

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can be classified either as constitutive pigmentation or facultative pigmentation.[12] Constitutive skin color is defined as the basal or genetically determined color in the absence of any external factor such as sunlight. It is generally taken to be the level of pigmentation in those parts of the body normally shielded from light such as upper volar arm, buttocks and mid-back. Facultative skin color is that which develops following direct exposure of the skin to a stimulant such as sunlight.[13] The facultative color change is considered to be reversible in that the hyperpigmentation of the skin tends to decline toward the constitutive level when exposure to ultraviolet light is discontinued.[14] Examples of facultative skin color at photo-exposed sites are posterior calf, forehead and dorsal forearm, etc. Among these 2 types of skin colors, constitutive skin color measurement from the upper volar arm provides a rapid, noninvasive, easily accessible and reliable method to objectively determine six different Fitzpatrick skin.[15] In this study, skin color was assessed at upper volar arm presenting constitutive skin color. Therefore, the aim of the present study was to explore the serum vitamin D level in young adults and its association with estimated sunlight exposure time and skin color.

MATERIALS AND METHODS

A total of 143 young adult subjects aged 21-39 years were recruited. Participants were explained about aim and objectives and procedures of the study. Then, written informed consent was taken individually. Subjects were selected according to inclusion and exclusion criteria. Inclusion criteria were as follows: apparently healthy male and female subjects, age 21-39 years, BMI ≥18.5 kg/m², no known history of diseases such as diabetes, hypertension, heart diseases, chronic kidney disease, chronic liver disease, bile duct diseases, inflammatory bowel disease and overt hyperparathyroidism. Those who underwent gastric bypass and bowel surgery and those who are taking medications such as steroids, anti-epileptics, anti-retroviral and anti-tuberculous drugs were excluded. Those who are taking pills or tablets that contain vitamin D, calcium and cod liver oil within previous one month were also excluded.

Methods

Serum vitamin D level was measured by enzyme-linked immunosorbent assay (Crystal Chem, Inc. USA). Vitamin D status was categorized into 3 groups: vitamin D sufficiency (serum 25(OH)D level ≥32 ng/mL), vitamin D insufficiency (serum 25(OH)D level 20-<32 ng/mL), vitamin D deficiency (serum 25(OH)D level <20 ng/mL).[5]

Estimated sunlight exposure time was assessed by questionnaires. Firstly, subjects were asked about their work, travelling history and estimated time spent outdoors during one month period. Then, they were asked a question to assess estimated sunlight exposure time: "How long are you in direct natural sunlight to upper and lower limbs and face per day during 10 A.M. to 3 P.M.?". Estimated sunlight exposure time is defined as time that is estimated to get exposed to natural sunlight to upper and lower limbs and face between 10 A.M. and 3 P.M. It was expressed as 2 groups: subjects with exposure time ≥30 min per day and those with exposure time <30 min per day. Three more questions were also asked: "Do you use sunscreen or thanaka (a paste made from ground bark, which is a distinctive feature of the culture of *Myanmar*) on your face/arms?" (always/sometimes/never use sunscreen or thanaka), "Do you use hat or umbrella when you go outside?" (always/sometimes/never), "Do you wear (usually/sometimes) long sleeve tops when you go outside?".

Skin color was assessed by using skin tone sensor facial skin analyzer (DEESS GP531, China). Skin color is defined according to Fitzpatrick skin type scale.[15,16] Light skin color includes Fitzpatrick skin type I, II, and III, and dark skin color includes Fitzpatrick skin type IV, V and VI.

Study Procedure

A total of 143 young adult subjects were recruited according to the inclusion and exclusion criteria and were asked for their voluntary participation. Written informed consent was taken from them. Then, they were instructed to come to Postgraduate Research Laboratory, Physiology Department, University of Medicine 1, Yangon at 8 A.M. For manual workers working at *Bayintnaung* Brokers' Sales Center, they were instructed to come to office room at center at 8 A.M. At department or *Bayintnaung* Brokers' Sales Center, a separate area was prepared for anthropometric measurement to get full privacy for them. Personal data collection, skin color assessment, and physical examination were done.

After that, 3 mL of venous blood sample was collected from antecubital vein under a strict aseptic condition and kept in a test tube with no anti-coagulant. For blood samples from Brokers' Sales Center, test tubes were placed in mini cooler box and taken to Postgraduate Research Laboratory, Physiology Department, University of Medicine 1, Yangon. After that, serum separation was done by centrifuging the test tubes at 3000 rpm for 15 min. Then, the serum was transferred into Eppendorf tube, which was then stored at (-20°C) in Post-graduate Research Laboratory of Department of Physiology, University of Medicine 1 for determination of serum 25(OH)D level.

Statistical Analysis of Data

Data was analyzed by using Statistical Package for Social Science (SPSS) software version 16. The results were expressed as mean±SD. Comparison of serum 25(OH)D level among different subject groups according to estimated sunlight exposure time and skin color were done by Independent Sample "*t*" test. Association of serum vitamin D status with estimated sunlight exposure time and skin color was calculated by using Chi-square test.

RESULTS

A total of 143 young adults (77 males and 66 females) were included in the study. The baseline characteristics of the participants are summarized in Table 1. The mean age was comparable between males (29.77±5.07 years) and females (30.15±5.59 years). Males had higher mean body weight (72.62±18.85 kg) and height (166.66±6.58 cm) compared to females (67.49±15.26 kg and 155.99±6.92 cm, respectively). The mean BMI was slightly higher in females (27.76±5.85 kg/m²) than in males (25.97±5.92 kg/m²).

Among 143 young adult subjects, 97 subjects (67.8%) were vitamin D sufficient, 41 subjects (28.7%) were vitamin D insufficient, and 5 subjects (3.5%) were vitamin D deficient. Serum 25(OH)D levels of male (n=77) and female (n=66) were 38.92±10.73 ng/mL and 32.27±7.43 ng/mL respectively (p<0.001). Among 77 male subjects, 58 subjects (75.3%) had vitamin D sufficiency, 17 subjects (22.1%) had vitamin D insufficiency and 2 subjects (2.6%) had vitamin D deficiency. Of the 66 female participants, 39 (59.1%) had sufficient levels of vitamin D, 24 (36.4%) had insufficient levels, and 3 (4.5%) were deficient in vitamin D.

Figure 1 compares serum vitamin D levels between participants with light and dark skin. Individuals with light skin had

significantly lower serum vitamin D levels compared to those with dark skin (p<0.01). Figure 2 demonstrates that participants who had estimated sunlight exposure of ≥30 min per day had significantly higher serum 25(OH)D levels than those with <30 min per day (p<0.001). Statistically significant association was found between vitamin D status and estimated sunlight exposure time and skin color in study population (Table 2).

DISCUSSION

In the present study, the majority of young adults had sufficient vitamin D level (67.8%). The percentage of vitamin D insufficiency and deficiency (28.7%, 3.5% respectively) was quite lower than three previous studies conducted in Myanmar, but these studies were done in 8-9-year age group (38.64%) and in 9.1-10-year age group (54.29%),[6] in elderly women (93.67%)[8] and in postmenopausal women (89%).[9] As young adults have more outdoor activities, they might get more sunlight exposure than children and elderly who spend most of their time staying indoors.

The percentage of hypovitaminosis in adolescents and adults varies among Asian countries. It was stated that 57.8% had vitamin D insufficiency and 31.2% had vitamin D deficiency in adolescent girls from Beijing,[17] 39% had vitamin D deficiency in young women of university students from Bangladesh,[18] and 46% of adult women and 20% of adult men from Vietnam had vitamin D insufficiency.[19] Moreover, some studies described that 32% of young adults from Australia had vitamin D deficiency[20] and 19.29% of young adults from Denmark had vitamin D deficiency.[21] It is reported that exposure of the skin to sunlight

Table 1: Baseline characteristics of young adults.

Variables	Male	Female	Total
	(*n*=77)	(*n*=66)	(*n*=143)
Age (years)	29.77±5.07	30.15±5.59	29.94±5.3
Body weight (kg)	72.62±18.85	67.49±15.26	70.25±17.42
Height (cm)	166.66±6.58	155.99±6.92	161.74±8.58
BMI (kg/m^2)	25.97±5.92	27.76±5.85	26.79±5.94

Table 2: Association between serum 25(OH)D and estimated sunlight exposure time and skin color in young adults.

	Vitamin D ≥32 ng/mL	Vitamin D <32 ng/mL	Total	χ2	p-value
	n (%)	n (%)			
According to estimated sunlight exposure time					
Total (n=143)					
≥ 30 mins per day	44 (95.7%)	2 (4.3%)	46 (32.2%)	24.05	<0.001
<30 mins per day	53 (54.6%)	44 (45.4%)	97 (67.8%)		
Total	97 (67.8%)	46 (32.2%)	143 (100%)		
According to skin colour					
Light skin	36 (58.1%)	26 (41.9%)	62 (43.4%)	4.79	<0.05
Dark skin	61 (75.3%)	20 (24.7%)	81 (56.6%)		
Total	97 (67.8%)	46 (32.2%)	143 (100%)		

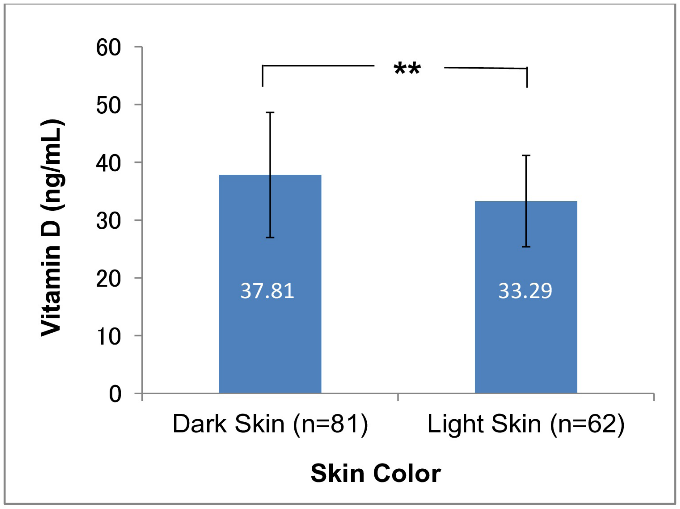

Figure 1: Comparison of serum vitamin D level between dark skin and light skin-colored subjects. ** indicates significant difference between two groups p<0.01.

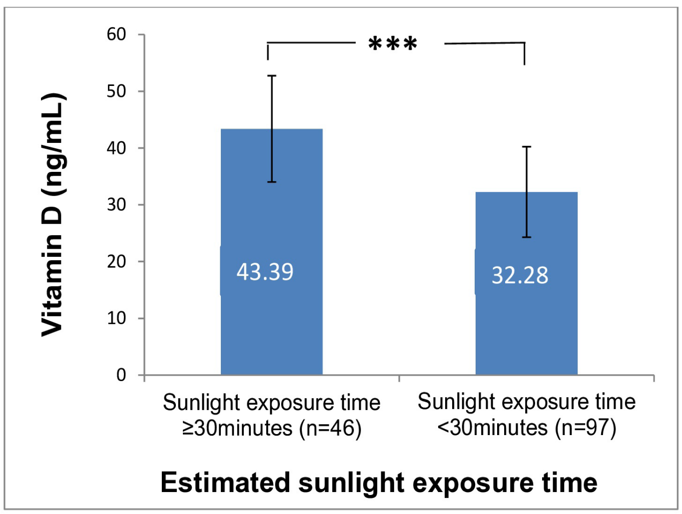

Figure 2: Comparison of serum vitamin D level between estimated sunlight exposure time ≥30 min and <30 min. ** indicates significant difference between two groups p<0.001.

typically between 10 A.M. and 3 P.M. is the best time to get vitamin D as the sunlight in this time period contain mostly UVB.[1,22] It has been recommended that approximately 30 min of skin exposure (without sunscreen) of arms and face to sunlight can provide all the daily vitamin D needs of the body.[23] Thus, in the present study, we asked the subjects about direct sunlight exposure time during 10 A.M. and 3 P.M. Hypovitaminosis was also found in only 2 subjects (4.3%) among those ≥30-min exposure time and 44 subjects (45.4%) among those with <30-min exposure time, indicating less sunlight exposure time having more risk of vitamin D deficiency. In addition, a statistically significant association was also noted between serum 25(OH)D status and different groups of estimated sunlight exposure time in study population (p<0.001), male subjects (p<0.001) and female subjects (p<0.05).

Skin pigmentation also determines the amount of previtamin D_3 synthesis in the skin.[24] In response to UV radiation, melanin dissemination alters, and its synthesis increases in the skin. Melanin efficiently absorbs and distributes electromagnetic radiation across the entire UV and visible light range and competes with 7-dehydrocholesterol for UVB photons, thus inhibiting the efficiency of previtamin D_3 synthesis.[25] Clemens *et al.* (1982) reported that those with darker skin require at least six-fold greater UVR dose than those with lighter skin to increase circulating levels of vitamin D. Thus, light skin color favors cutaneous vitamin D synthesis.[10] Chen *et al.* (2007) showed that with the same duration of sunlight exposure time (i.e., 30 min) previtamin D_3 in type II skin-colored subjects was 2.78±0.09% and that in type V skin-colored subjects was 0.29±0.5%.[26] Likewise, Poopedi, Norris and Pettifor (2011) reported that vitamin D levels in white skin color was 48±14.64 ng/mL and that of black skin color was 37.32±3.62 ng/mL in 10-year-old children (p=0.01).[27] Contrary to these studies, the present study found that those with dark skin color had higher vitamin D level than those with fair skin color. It could be explained by longer exposure time in participants with dark skin color. Dark skin-colored subjects are manual workers who always work at least 3-4 hr outdoors without using any sun protective measures such as sunscreen, umbrella or hats. Similar to the present finding, lower vitamin D level was found in fair skin individuals with lower sun exposure compared to dark skin individuals with higher sun exposure (p<0.001).[11]

Moreover, among the 143 participants, 105 (73.4%) were Burmese, while the remaining 38 participants (26.6%) belonged to various other ethnic groups including Kayin, Mon, Rakhine and Shan. No association was found between ethnicity and vitamin D levels. While some studies suggested a link between serum vitamin D levels and ethnicity, no such relationship was observed in this study.[28,29] The present study indicated that skin pigmentation directly influences serum vitamin D levels, regardless of ethnicity.

LIMITATION OF THE STUDY

Another important determinant of vitamin D status in the body is dietary intake of vitamin D. The limitation of this study is that dietary intake of vitamin D rich food was not recorded. Further study is recommended to shed light on the importance of sunlight exposure and dietary intake of vitamin D on body's vitamin D status.

CONCLUSION

It can be assumed that both skin color and estimated sunlight exposure time are contributing factors for determining serum vitamin D level.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

25(OH)D: 25-hydroxyvitamin D; **BMI**: Body Mass Index; **ELISA:** Enzyme-Linked Immunosorbent Assay; **IU:** International Units; **mL:** Milliliter; **nm:** Nanometer; **nmol/L:** Nanomoles per Liter; **ng/mL:** Nanograms per Milliliter; **rpm:** Revolutions per Minute; **UVB:** Ultraviolet B.

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