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Occurrence of Vitamin D Deficiency among Women in North Sumatera, Indonesia

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ABSTRACT

Introduction: Low levels of serum 25(OH)D in women are reported in temperate countries, and increasingly so in tropical countries but few such studies have been reported in Indonesia. This study was aimed at assessing the serum vitamin D status and its associated factors in a sample of Indonesian women **Methods**: A cross-sectional study was conducted on 156 apparently healthy women during the dry season in North Sumatera. The measurements carried out included exposure to sun's rays, intake of vitamin D food sources, reported physical activity, body fatness (by bioelectrical impedance analysis), and serum 25(OH)D levels (by chemiluminescent immunoassay). Serum 25(OH)D levels were categorised into: deficient(<20 ng/mL), insufficient (20-32 ng/mL), sufficient (32-100 ng/mL), and normal for tropical countries (54-90 ng/mL). Statistical analysis included Pearson correlation, independent *t*-test, and one way ANOVA tests. **Results**: The mean age of the subjects was 35.6±7.7 years, with about 70% working indoors. About half of the women were obese. The majority had low vitamin D intake. More than half had sun ray exposure of less than 1 hour, and moreover, nearly two-thirds of them wore the 'hijab' that covers most parts of their body. The majority of women reported low physical activity level. The mean serum 25(OH)D level of the subjects was 17.71 ng/mL (95% CI: 16.22, 19.34 ng/mL). Of the total, 95% (148) were in the vitamin D deficient-insufficient category, with the remaining 5% in the sufficient category. An association was found between occupation, dietary intake of vitamin D, sun ray exposure, and physical activity levels with serum vitamin D concentrations. **Conclusion**: The results showed that vitamin D deficiency can occur in women living in a tropical country if they have sun-avoiding lifestyles, work indoors, and have low dietary intake of vitamin D.

Key words: Occupation, serum 25(OH)D levels, sun ray exposure, vitamin D food sources

INTRODUCTION

Deficient or insufficient vitamin D occurs in approximately one billion people around the world. The increase in prevalence of vitamin D deficiency is increasingly being reported in temperate and tropical countries (Sachan *et al.*, 2005; Roy *et al.*, 2007; Strand *et al.*, 2007).

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A study in Southern India showed that 52% of 164 post-menopausal women had vitamin D insufficiency, and 30% had vitamin D deficiency. Vitamin D deficiency in Malaysia was reported by Rahman *et al.* (2004) in 27% of a sample of post-menopausal women while 71% of them had vitamin D insufficiency.

Decreased bone mineral density has been reported to occur in 10-18 year-old subjects (Lips, 2001; Marwaha *et al.*, 2005). Rickets and osteomalacia in infants and children, and risk of osteoporosis in post-menopausal women are reportedly on the rise in South Asia (Harinarayan, 2005; Siddiqui & Rai, 2005).

Vitamin D deficiency also occurs due to occupational lifestyle, duration of sun ray exposure, extent attire covers the body, use of sunscreen, physical activity, and intake of vitamin D from food and dietary supplements (Ogunkulade *et al.*, 2006; Masood & Iqbal, 2008; Holick, 2005). Studies have also shown that as body fatness increases, serum 25(OH)D levels decreases. Vitamin D is stored in the adipocytes and not released to the circulation, causing low vitamin D concentrations in the circulation (Cheng *et al.*, 2010).

This study aims to determine the association between lifestyle factors and body fatness and serum 25(OH)D levels in women.

METHODS

Study design and subjects

This cross-sectional study recruited subjects by convenient sampling from government and private organisations in Medan City, North Sumatera, Indonesia. Prior to recruitment in each organisation, the research team comprising doctors, nurses and laboratory staff gave a presentation about this research. The subjects signed the informed consent form prior to data collection.

The inclusion criteria were apparently healthy women between the ages of 20-50 years and not receiving treatment for gastrointestinal, liver and kidney disorders. Subjects were excluded if they were pregnant, lactating, using medications that could alter lipid profiles, and had a history of diabetes mellitus, myocardial infarction, renal or liver dysfunction.

Lifestyle factors included six variables namely, occupation, intake of vitamin D food, sun ray exposure per day, dress style, sunscreen application, and physical activity. Occupation was categorised into indoor type (most of the working time spent inside the building (e.g. bank employees, teachers, doctors, and nurses) or outdoor type (most of the working time spent in the field or street, i.e. farmers and street cleaners).

Dietary intake of vitamin D was assessed using food recall for two days (including one non-working day), while estimation of dietary vitamin D contents was by using the Nutrisurvey 2005 which included data on Indonesian cuisines. Intake of vitamin D supplements was included.

The cumulative sun ray exposure per day was divided into two groups namely, $\leq$1 hour and >1 hour per day with the question being about how long they were exposed to sun ray throughout the day. Women wearing the *hijab* are less exposed to sun rays as the *hijab* covers the whole body except for the face and hands. Application of sunscreen and facial whitening cream were also included in the interview in relation to subjects' perception of sun-avoiding lifestyle.

Physical activity was assessed using the Baecke's questionnaire which includes questions on how many times and how long they carry out routine physical activity throughout the day and week. The answers were categorised into low and moderate levels of physical activity (Baecke, Burema & Frijters, 1982).

Anthropometric status and body fatness

Body mass index (BMI) and body fatness were assessed using the Body Composition Monitor with Scale (HBF-362, KaradaScan-Omron). The BMI categories were based on the Asia-Pacific criteria using the following categories: not obese ($\leq$24.9 kg/m^2) and obese (>25 kg/m^2) and body fatness expressed as body fatness percentage (%). Abdominal circumference was measured using a non-plastic measuring tape.

Serum vitamin D

Serum 25(OH)D level was determined using the chemilluminescent immunoassay (CLIA) technology (Diasorin, Stillwater, MN, USA). This measurement can detect levels ranging from 4.0 and 150 ng/mL, based on 3.90% CV inter-assay precision. Serum 25(OH)D levels were categorised into: deficient (<20 ng/mL), insufficient (20-32 ng/mL), sufficient (32-100 ng/mL), and normal for tropical countries (54-90 ng/mL) (Grant & Holick, 2005). Serum calcium levels were measured using ADVIA Assayed Chemistry Controls (Bayer, Germany), where the normal level of serum calcium is 8.3–10.6 mg/dL.

Statistical analysis

Numerical variables were used to indicate mean ± standard deviation, while categorical variables were used to indicate the percentage values of proportion. Association between numerical independet variable and 25(OH)D concentrations were determined using Pearson correlation. Comparing the mean values between categorical independent variables and vitamin D concentrations were determined using independent *t*-test and expressed as geometric mean (95% CI). Association between categorical independent variables and vitamin D concentration were determined using oneway anova and expressed as geometric mean (95%CI); 25(OH)D concentration was transformed by log10 and was back transformed for data presentation. Logistic regression analysis was used to identify prediction factors. This study used SPSS program (version 11.5; SPSS Inc, Chicago, IL, USA) for data analysis.

Ethical approval was obtained from the Health Research Ethics Committee of Sumatera Utara University Medical School.

RESULTS AND DISCUSSION

The mean age of the subjects was 35.6±7.7 years. The subjects had a mean BMI of 25.5 ±4.7 kg/m^2 with 50% obese with body fatness of 31.99% ± 5.42 (Table 1). Two-thirds (68.6%) of the subjects worked indoors, 82.7% had low vitamin D intake, 53.2% had sun ray exposure of less than 1 h, 61.5% of the women wore the *hijab*, 75% used sunscreen, and 65.4% had low physical activity level.

The mean serum 25(OH) D level was 17.71 ng/mL, CI 95%: 16.22-19.34. About 94.9% of the subjects were categorised as deficient-insufficient, while 5.1% as sufficient; none of the study participants reached normal category for sunny areas. Percentile 25-75 of vitamin D value were in the range of 13.2-22.9 ng/mL; the normal range in the population, with minimum percentile was 7.1 ng/mL and maximum percentile was 42.5 ng/mL (Table 2).

Serum vitamin deficiency levels were significantly associated with indoor occupation [p<0.001, 14.81 ng/mL (CI95% 13.98, 15.70)], low dietary intake of vitamin D food [p=0.046, 17.03 ng/mL (15.98, 18.16)], with $\leq$1-hour sun ray exposure per day [p<0.001, 14.29 ng/mL (13.28, 15.39)], and reported low physical activity [p<0.01, 15.97 ng/mL (14.90, 17.11)] (Table 3). After adjusting for related factors, the multivariate model revealed that less than 1 hour sun ray exposure per day, indoor occupation, and low dietary vitamin D intake were all significant independent correlates of deficient-insufficient vitamin D (Table 4).

The finding on dietary intake concurs with Brock *et al* (2010) who reported that vitamin D intake was a predictive factor for the development of vitamin D deficiency.

Table 1. Characteristics of subjects (N=156)

	Mean ± SD
Age (years)	35.60±7.68
Anthropometry	
BMI (kg/m²)	25.49±4.70
Waist circumference (cm)	83.35±11.04
Body fatness percentage (%)	31.99±5.42
Dietary intake of vitamin D (mg)	5.24±6.94
Serum Calcium (mg/dL)	9.11±0.49
	N (%)
Obesity	
Yes	50 (78)
No	50 (78)
Occupation	
Indoors	107 (68.6)
Outdoors	49 (31.4)
Vitamin D intake	
Low	129 (82.7)
Moderate	27 (17.3)
Sun ray exposure per day	
≤1 hour	83 (53.2)
>1 hour	73 (46.8)
Dressing style	
Hijab	96 (61.5)
No *hijab*	60 (38.5)
Sunscreen application	
Yes	117 (75.0)
No	39 (25.0)
Physical activity	
Low	102 (65.4)
Moderate	54 (34.6)

Table 2. Prevalence and classification of serum 25-hydroxyvitamin D concentrations

	Mean (95% CI)
25-hydroxyvitamin D serum (ng/mL)#	17.71(16.22, 19.34)
Classification	N (%)
Deficiency-insufficiency	148 (94.9)
Sufficiency	8 (5.1)
Percentile of vitamin D value	
Minimum	7.1
Percentile 5	9.4
Percentile 25	13.2
Percentile 50	18.4
Percentile 75	22.9
Percentile 95	32.1
Maximum	42.5

#Because of non normal distribution, 25(OH)D concentration was transformed by log10 and backtransformed for data presentation [geometric mean(CI95%)]

Table 3. Association between age, anthropometry, lifestyle, vitamin D food sources intake, and calcium serum with vitamin D concentration

Variables	*Coefficient correlation or geometric mean (CI95%)*	*p value*
Age (years)	0.101	0.209
Occupation		
Indoors (n=107)	14.81(13.98-15.70)	
Outdoors (n=49)	25.22(23.72-26.82)	<0.001
Anthropometry		
BMI (kg/m^2)	-0.009	
Waist circumference (cm)	-0.030	
Body fatness percentage (%)	-0.093	
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Obesity		
Yes (n=78)	17.31(15.99-18.73)	
No (n=78)	17.71(16.22-19.34)	0.700
Vitamin D food sources intake (mg)	0.117	0.144
Vitamin D intake		
Less (n=129)	17.03(15.98-18.16)	
Moderate (n=27)	19.96(17.34-22.99)	0.046
Sun ray exposure per day		
≤1 hour (n=73)	14.29(13.28-15.39)	
>1 hour (n=83)	20.93(19.51-22.46)	<0.001
Dressing style		
Hijab (n=96)	17.53(16.24-18.92)	
No hijab (n=60)	17.48(15.92-19.19)	0.966
Sunscreen application		
Yes (n=117)	17.96(16.78-19.22)	
No (n=39)	16.23(14.43-18.24)	0.145
Physical activity		
Low (n=102)	15.97(14.90-17.11)	
Moderate (n=54)	20.84(18.96-22.90)	<0.01
Biochemical biomarkers		
Calsium serum (mg/dL)	0.048	0.552

#association between numerical independent variable and 25(OH)D level analysed using Pearson correlation and expressed as *r*; association between dichotomous categorical independent variable and 25(OH)D level were analysed using independent *t*-test and expressed as geometric mean (95%CI); association between polikotom categorical independet variable and 25(OH)D level were analysed using one-way ANOVA and expressed as geometric mean (95%CI); 25(OH)D level was transformed by log10 and was backtransformed for data presentation.

Women in this study showed a wide range of vitamin D intake with some subjects reporting non consumption of vitamin D, and some reported consuming vitamin D in high amounts. Vitamin D food sources were egg yolk, fish, and meat. However, food sources alone are not adequate to supply sufficient vitamin D intake. According to a study by Masood & Iqbal (2008), the inability to buy vitamin D food sources was a cause of vitamin D deficiency. Salmon and fish oil are expensive food sources in the market. Mushroom can be easily obtained, but in some regions such as Sumatera, mushroom is not a food that is regularly consumed. Mushroom is more often regarded as a herbal medicine and not a regularly consumed food.

Table 4. Multivariable analysis to find vitamin D deficiency predictive factors

Final model#	*Unstandardised Coefficients*		*Standardised Coefficients*	*p value*
	B	*Std. Error*	*(Beta)*	
Constant	0.897	0.033		<0.001
Sun ray exposure per day	0.058	0.024	0.177	0.019
Occupation	0.190	0.026	0.543	<0.001
Dietary intake of vitamin D	0.046	0.026	0.107	0.076

#Only for final model; Variable included in the multivariable analysis were age, ethnicity, systolic blood pressure, diastolic blood pressure (mmHg), intake of carbohydrate, intake of fat/day, sun ray exposure per day, occupation, sunscreen application, physical activity, and vitamin D intake classification.
Formula to predict 25(OH)D level was 10^y.
y=0.897 + 0.058(sun ray exposure) + 0.190(occupation) + 0.046(vitamin D intake classification).
Coding for sun ray exposure per day: 0 ($\leq$1 hours) and 1 (>1 hours); Coding for occupation: 0 (indoor) and 1 (outdoor); coding for classification of vitamin D intake: 0 (less) and 1 (moderate).

This study showed contrasting results compared to other studies (Liel *et al.*, 1988; Bell *et al.*, 1985; Khor *et al.*, 2011), in that we found low serum 25(OH)D levels not in only women with high body fatness but also in subjects with normal and low body fatness. The average serum 25(OH)D levels were not related to obesity status of the subjects. The results indicate that low levels of serum 25(OH)D may occur in a tropical country like Indonesia regardless of the women being obese or otherwise. It is speculated that body fat layers lead to low levels of vitamin D circulation by trapping vitamin D inside fat cells.

Women face a higher risk for having vitamin D deficiency than men, due to their lifestyle which tends to be spent indoors to avoid sun rays. Not only housewives, working women also spend more time indoors. The urban middle class lives in crowded areas (such as flats or apartments) with little exposure to sun rays (Masood & Iqbal, 2008). Sunscreen is more widely used by women than men. A study by Abroms *et al.* (2003) reported that with reasonable action theory, men and women are different in behaviour, beliefs and normative beliefs. The study found that women were more aware of sunscreen usage as a preventive measure than men, who were more reactive in style. The study indirectly found that the reason for sunscreen usage was not to avoid skin cancer, but more directed towards cosmetics reason. The perception that a whiter skin is more beautiful has a greater impact on a woman's confidence compared to a darker skin.

Sun ray exposure also played an important role in vitamin D synthesis. In this study, all the subjects did not reach normal value of 25(OH)D level, probably because of less sun ray exposure. This result was differed slightly from the results obtained by Wortsman *et al.* (2000); Martini & Wood (2006) mention a few causes associated with vitamin D deficiency and obesity, including individual activity with low exposure to sun rays, the accumulation of vitamin D in adipose tissues, and the decrease in bioavailability of endogenous vitamin D production in the circulation. According to Holick (2007), the easiest way to determine sufficient duration of sun ray exposure required for vitamin D production is by exposing the face, arms and hands to sun rays for a duration equal to 25% of the time needed to produce 1 MED. For example, highest intensity (2 MED) occurs at 11.00-13.00 AM, and thus the time needed is:

Maximum initial exposure time = ¼ x 1 MED/y MED x 60 minutes y = the amount of UV B radiation emission according to time of exposure (in MED)

From this formula , we get ¼ x 1 MED/2 MED 60 minutes = 7.5 minutes. Therefore, if the exposure is at noon (11.00 AM), the duration needed to produce sufficient amounts of vitamin D is 7.5 min. If the exposure is 0.6 MED at 09.00 AM, then the time required to increase serum 25(OH)D level is ¼ x 1/0,6 x 60 minutes, which means 25 min for each exposure.

Holick (2006) estimated that whole body exposure of 1 individual MED will be equal to consumption of 10,000 IU of vitamin D. Exposure of 1 MED to 6-10% of body surface will be equal to consuming 600-1000 IU. The latest recommendation of adult vitamin D daily intake is 200 IU, although this study suggested increasing vitamin D intake up to 600 IU (by increasing daily intake up to 4000 IU) without exposure to sun rays. According to data, 1 MED exposure to 6-10% of body surface (one arm, one leg, or face and hand) is adequate to maintain the level of vitamin D (Holick, 2006)

As the predictive factors were sun ray exposure per day, occupation, and vitamin D intake, the formula to predict serum 25(OH)D level was: 10^y.y=0.897 + 0.058(sun ray exposure) + 0.190(occupation) + 0.046(vitamin D intake classification) [Coding for Sun ray exposure per day: 0 ($\leq$1 h) and 1 (>1 h); Coding for occupation: 0 (indoor) and 1 (outdoor); coding for classification of vitamin D intake: 0 (less) and 1 (moderate)]. This formula could predict the probability of vitamin D deficiency in healthy Indonesian women.

CONCLUSIONS

This study reported vitamin D deficiency among women in a tropical country, especially those with less than 1 h/day of sun ray exposure, having indoor occupations and inadequate intake of vitamin D and indulging in low physical activity level.

Conflict of Interest

There is no conflict of interest in this research.

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