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Vitamin D deficiency and depression among women from an urban community in a tropical country

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Abstract

Objective: To determine the association of vitamin D status with depression and health-related quality of life among women.

Design: This was a cross-sectional study conducted among women in Kuala Lumpur, Malaysia. Sociodemographic characteristics, physical activity status, perceived depression and health-related quality of life were assessed via a self-administered questionnaire. Fasting blood samples were taken for the analysis of 25-hydroxyvitamin D, parathyroid hormone, fasting blood glucose and full lipid profile. Complex samples multiple logistic regression analysis was performed.

Setting: Public secondary schools in Kuala Lumpur, Malaysia.

Subjects: Seven hundred and seventy female teachers were included.

Results: The mean age of participants was 41·15 (95 % CI 40·51, 41·78) years and the majority were ethnic Malays. Over 70 % of them had vitamin D deficiency (<20 ng/ml or <50 nmol/l) and two-thirds were at risk for depression. In the multivariate analysis, ethnic Malays (adjusted OR (aOR) = 14·72; 95 % CI 2·12, 102·21) and Indians (aOR = 14·02; 95 % CI 2·27, 86·59), those at risk for depression (aOR = 1·88, 95 % CI 1·27, 2·79) and those with higher parathyroid hormone level (aOR = 1·13; 95 % CI 1·01, 1·26) were associated with vitamin D deficiency, while vitamin D deficiency was negatively associated with mental health-related quality of life (Mental Component Summary) scores (aOR = 0·98; 95 % CI 0·97, 0·99).

Conclusions: Vitamin D deficiency is significantly associated with depression and mental health-related quality of life among women in Kuala Lumpur, Malaysia.

Keywords
Vitamin D deficiency
Depression
Quality of life
Women
Tropical country

Vitamin D deficiency is a global public health problem affecting a billion people worldwide[1]. Malaysia is a tropical country located near the equator. Being close to the equator, Malaysia enjoys abundant sunshine throughout the year. On average, Malaysia receives about 6 h of sunshine per day. With the exception of the monsoon seasons, it is extremely rare for Malaysians to have a stretch of days with completely no sunshine. However, the Malaysian population, especially the ethnic Malay and Indian women, have been found to be more susceptible to vitamin D deficiency[2,3]. The role of vitamin D is well established in Ca homeostasis and bone health[4,5]. Current evidence shows that vitamin D deficiency is also associated with increased risk for metabolic syndrome (MetS), certain types of cancer, type 2 diabetes mellitus and CVD[6,7].

Depression is one of the leading causes of disability and mortality worldwide. Globally, about 840 million people suffer from depression[8]. The National Health and Morbidity Survey (NHMS) 2011 in Malaysia reported that the prevalence of lifetime depression and current depression was 2·4 % and 1·8 %, respectively[9], using the Mini International Neuropsychiatry Interview (MINI). Although there is a variation in the prevalence of depression using different tools, mental health problems namely depression are health conditions that should not be overlooked. Its consequences include impairment in functional well-being and poorer quality of life[10,11], physical distress and health problems[12].

A systematic review by Anglin *et al.*[13] found an increased odds/risk of depression for the lowest *v.* highest vitamin D categories in cross-sectional studies (OR = 1·31; 95 % CI 1·0, 1·71) as well as cohort studies (hazard ratio = 2·21; 95 % CI 1·40, 3·49). Ecemis and Atmaca[14] found that quality of life was impaired in vitamin D-deficient and -insufficient premenopausal women. On the other hand,

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studies by Zhao *et al.*[15] and Nanri *et al.*[16] reported no significant association between vitamin D status and depressive symptoms. However, all this evidence was from Western populations. There is a scarcity of evidence in the East especially among tropical countries with an abundance of sunshine, like Malaysia.

Women's daily life and interpersonal relationships may be affected by vitamin D deficiency in addition to depression. Having observed such a high prevalence of vitamin D deficiency among women in Malaysia, and since depression also has a detrimental effect on well-being, there is an urgent need to study this relationship. Therefore, we aimed to study the association between vitamin D status, depression and health-related quality of life among women in Kuala Lumpur, Malaysia.

Methods

Study design

This was a cross-sectional study conducted between March and October 2013.

Study setting, study participants and ethics clearance

The study was conducted in public secondary schools in Kuala Lumpur, the federal capital of Malaysia. Kuala Lumpur is divided into four districts with a total of eighty-seven public secondary schools. Each district has about twenty to twenty-three schools. All female teachers without any known psychiatric problems (assessed through self-report in the questionnaire) were invited to participate in the study. Female teachers were selected as they form one of the largest female occupational groups (other than nurses) in Malaysia. They are also the caregivers of their families and educators for the future generation and therefore need to have optimum health in order to perform these multiple tasks.

Ethics clearance was obtained from the Medical Ethics Committee (an independent review board in our medical faculty) that governs all research projects involving human subjects (reference number: MEC 950.1). Approval to conduct the study was obtained from the Ministry of Education, Malaysia; the Kuala Lumpur Education Department (the local education department); and the respective school principals. Written informed consent was obtained from all participants prior to the study.

Sampling method

A two-stage sampling process was used in the recruitment of teachers. Ten schools from each of the four districts in Kuala Lumpur were randomly selected and invitation letters were sent to these schools. All tenured female teachers from schools who agreed to participate and who fulfilled the criteria were invited to participate in the study. Participation was voluntary.

Data collection

A validated and pre-tested questionnaire was self-administered by all participants. Information collected in the questionnaire included sociodemographic characteristics, medical history, physical activity using the Malay version of the International Physical Activity Questionnaire (IPAQ) – short form[17], depression using the Malay version of the Depression, Anxiety and Stress Scale (DASS) 21[18] and health-related quality of life using the Malay version of the SF12-v2 Health Survey[19].

Physical activity was categorized into low, moderate and high using the IPAQ – short form. Low and moderate categories were grouped as physically inactive. The total score on depression was summed and multiplied by two. Scores of less than or equal to 9 points were considered normal, while risk of depression was arbitrarily cut off at more than 9 points[20]. Mental and physical health-related quality of life were assessed using the SF12v2's Mental Component Summary (MCS) and Physical Component Summary (PCS) scores[21]. Higher scores indicated better mental or physical health-related quality of life.

Participant's weight was measured in light clothing with shoes removed, to the nearest 0·1 kg, using a digital calibrated floor scale (SECA 813, Hamburg, Germany). Height was measured without shoes to the nearest 0·1 cm with a portable stadiometer (SECA 217). BMI was calculated in kg/m^2 and the cut-offs of overweight and obesity were set at 23·0 kg/m^2 and 27·5 kg/m^2, respectively, following the Asian standard[22]. Waist circumference was measured to the nearest 0·1 cm at the umbilicus, between the tenth rib and the iliac crest, using a flexible tape measure (SECA 203). The cut-off used to identify abdominal obesity among Malaysians was according to the Asian standards[23] where 80 cm is used for females. Resting blood pressure was measured using a clinically validated digital automatic blood pressure monitor (Omron model HEM-907). Fasting blood samples were drawn by trained nurses and sent to the Clinical Diagnostic Laboratory of the University of Malaya Medical Centre for the analysis of fasting blood glucose, full lipid profile, 25-hydroxyvitamin D (25(OH)D) and parathyroid hormone (PTH). Fasting lipid profile was analysed using the Dimension® clinical chemistry system which is an *in vitro* diagnostic test.

Vitamin D status was evaluated by measuring the concentration of the primary circulating form of vitamin D, which is serum 25(OH)D. The biochemical test used the electrochemiluminescence detection technology and the Cobas® modular platforms. Participants with 25(OH)D concentration <50 nmol/l or <20 ng/ml were classified as vitamin D deficient according to the Endocrine Society Clinical Practice Guidelines[24]. This recommendation was based on a medical model that has been proposed in order to prevent vitamin D deficiency and avoid other risks (besides bone health) related to inadequate vitamin D status. MetS was defined according to the harmonized criteria[25]. The study protocol has been published elsewhere[26].

Data analysis

Data were entered and analysed using the statistical software package SPSS Version 16. The significance level was pre-set at $P<0{\cdot}05$ and 95% confidence intervals were reported where appropriate. Sampling weights were applied to produce unbiased estimates, correcting for unequal selection probabilities and non-response, since two-stage sampling was used. Complex samples univariate analyses were used to describe the sociodemographic characteristics, medical history, MetS and vitamin D status of participants. Complex samples multiple logistic regression was performed to investigate the associations between vitamin D status and depression as well as mental health-related quality of life adjusted for race, age group, MetS, BMI, PTH and physical (PCS) health-related quality of life.

Results

The response rate for schools was 75% while the response rate from participants was 38%. A total of 770 female teachers were recruited. Table 1 shows that the majority of the participants were Malays, married and had tertiary education. Two-thirds of them were in their 30s and 40s. More than 70% of them were vitamin D deficient. About 22% had MetS, while only 5% and 8% of them had diabetes mellitus and hypertension, respectively. Two-thirds of them were overweight/obese and at risk for depression. The mean concentrations of 25(OH)D and PTH, and the mean scores for depression, physical (PCS) and mental health-related quality of life (MCS) are also presented in Table 1.

The associations of vitamin D deficiency with sociodemographic characteristics, health outcomes, depression and health-related quality of life are summarized in Table 2. In the unadjusted logistic regression analysis, vitamin D deficiency was associated with race, age group, MetS, depression and PTH. BMI and mental health-related quality of life (MCS) were marginally associated with vitamin D deficiency. In the multivariate logistic model, ethnic Malay and Indian women had higher

Table 1 Sociodemographic characteristics, medical history, metabolic syndrome, depression, quality of life and vitamin D status of participants: female teachers (*n* 770) from public secondary schools in Kuala Lumpur, Malaysia, March–October 2013

	Unweighted count	Weighted %
Race		
Malay	595	76·6
Chinese	116	15·0
Indian	59	8·4
Marital status		
Single/widowed/divorced	97	14·2
Married	562	85·8
Education levels		
Diploma	23	3·6
Degree	555	83·5
Master/PhD	79	12·9
Age group (years)		
20–29	104	13·0
30–39	255	32·6
40–49	262	34·4
≥50	149	19·9
Medical history		
Diabetes mellitus	32	5·2
Hypertension	47	8·1
Heart disease	9	1·6
BMI		
Underweight (<18·5 kg/m^2)	26	3·5
Normal weight (18·5–22·9 kg/m^2)	215	27·3
Overweight (23·0–27·4 kg/m^2)	281	37·2
Obese (>27·5 kg/m^2)	247	31·9
Vitamin D deficient (<20 ng/ml or <50 nmol/l)	557	72·2
Metabolic syndrome	168	22·2
Depression (score >9)*	440	68·0
	Mean	95% CI
Age (years)	41·15	40·51, 41·78
BMI (kg/m^2)	25·43	25·02, 25·83
25-Hydroxyvitamin D (ng/ml)	17·52	16·96, 18·09
Parathyroid hormone (pg/ml)	6·02	5·76, 6·27
Depression score*	14·36	13·62, 15·11
Physical Component Summary (PCS) score†	48·43	47·87, 48·99
Mental Component Summary (MCS) score†	47·48	46·83, 48·14

*Depression was measured using the Malay version of the Depression, Anxiety and Stress Scale[18] (DASS-21).
†Physical Component Summary (PCS) and Mental Component Summary (MCS) scores were measured using the Malay version of SF12-v2 Health Survey[19].

Table 2 Association of vitamin D deficiency (<20 ng/ml or <50 nmol/l) with sociodemographic characteristics, health outcomes, depression and health-related quality of life among female teachers (*n* 770) from public secondary schools in Kuala Lumpur, Malaysia, March–October 2013

	Crude OR	95 % CI	*P**	Adjusted OR†	95 % CI	*P**
Race						
Chinese	1·00 (Ref.)		0·02	1·00 (Ref.)		0·03
Malay	12·22	3·95, 37·84		14·72	2·12, 102·21	
Indian	10·24	4·79, 21·87		14·02	2·27, 86·59	
Age group						
50s	1·00 (Ref.)		0·01	1·00 (Ref.)		0·14
20s	2·65	2·03, 3·45		1·56	0·46, 5·23	
30s	1·79	1·07, 2·98		0·91	0·59, 1·41	
40s	1·70	1·43, 2·04		1·40	0·33, 5·86	
Physically inactive	1·54	0·32, 7·39	0·18	–		
Metabolic syndrome	1·33	1·20, 1·47	0·02	1·13	0·67, 1·90	0·21
Depression (score >9)	1·38	1·20, 1·58	0·02	1·88	1·27, 2·79	0·03
BMI	1·08	0·99, 1·17	0·05	1·03	0·99, 1·06	0·06
Parathyroid hormone	1·19	1·03, 1·36	0·04	1·13	1·01, 1·26	0·047
Mental Component Summary (MCS) score	0·99	0·97, 1·00	0·05	0·98	0·97, 0·99	0·01
Physical Component Summary (PCS) score	1·00	0·96, 1·04	0·82	–		

Ref., reference category.
*Derived from binary logistic regression.
†OR were adjusted for race, age group, metabolic syndrome, depression, BMI, parathyroid hormone, and MCS and PCS scores.

odds for vitamin D deficiency compared with ethnic Chinese. Vitamin D-deficient women were more likely to be depressed and had poorer mental health-related quality of life. Higher level of PTH was also associated with vitamin D deficiency.

Discussion

Malaysia is a tropical country located at the equator and is sunny all year round. However, over 70 % of our participants had 25(OH)D levels indicative of deficiency (<20 ng/ml or <50 nmol/l), comparable with two other studies conducted by Green *et al.*[2] and Moy and Bulgiba[3] which reported that 60 % and 87 % of premenopausal women in Kuala Lumpur had vitamin D deficiency, respectively, using the same cut-off value. Compared with studies from other tropical countries such as Vietnam[27] and Indonesia[2], our participants had higher proportions of vitamin D deficiency.

Similar to studies from Singapore which had similar age ranges and ethnic distribution[28,29], we found that ethnic Malay and Indian women had higher odds for vitamin D deficiency. Their skin pigmentation may predispose them to lesser vitamin D synthesis. Darker skin pigmentation is associated with decreased skin synthesis of vitamin D[30], as melanin reduces the penetration of UV light and thus contributes to vitamin D deficiency in individuals with darker skin[31].

It is postulated that vitamin D deficiency in a tropical and sun-rich country such as Malaysia is mostly due to the clothing style and sun avoidance behaviour[3]. Dressing styles of women, especially those constrained by culture or religions (wearing long sleeves, long skirts and scarf), may prevent or decrease the cutaneous surface available for sufficient sunlight exposure. Asian women also tend to prefer fairer skin and strive to do this through the application of sunscreen or sun shield when going outdoors as some believe that fairer skin is more beautiful than tanned skin[32]. In addition, Caucasians were found to have higher 25(OH)D levels than non-Caucasians[32] due to cultural influences with regard to sun exposure. The nature of our participants' occupation may also have contributed to their low vitamin D status as they were teachers who worked indoors most of the time. Therefore, their exposure to sunlight may be less than that of other occupational groups which have more outdoor work.

Vitamin D is fat-soluble and sequestered in adipose tissue, and is therefore low in serum among obese individuals[33]. There was a significant association between vitamin D and BMI in our univariate analysis; however, the result was attenuated and became marginally insignificant in the multivariate analysis. Other factors such as age and race may also have contributed to the level of serum 25(OH)D among our participants.

A systematic review by Parker *et al.*[7] found that the highest level of serum 25(OH)D was associated with a 43 % reduction in cardiometabolic disorders, while the results from more recent individual studies suggested an inverse association between 25(OH)D and cardiovascular risks[6] and metabolic risk factors[34]. On the contrary, we did not find any significant association of MetS or metabolic risk factors with vitamin D deficiency. These contradicting results could be due to the different cut-off levels used to define vitamin D deficiency in different studies. In addition, our participants were relatively young and cardiometabolic risks usually manifest among older age groups[35].

PTH was associated with vitamin D deficiency, similar to reports elsewhere[36,37]. PTH is secreted by the parathyroid

glands and is important in Ca homeostasis. PTH stimulates the increased biosynthesis of 1,25-dihydroxyvitamin D when the levels of 25(OH)D are low[38]. PTH may also contribute to depression through a possible mechanism in which low vitamin D level causes an increase in PTH level and hyperparathyroidism is often accompanied by depressive disorders[39].

Our results demonstrated that low vitamin D status was associated with higher levels of depression after adjusting for confounding variables in Malaysian women. Almost two-thirds of our participants were at risk for depression. This figure was much higher compared with the results from our national survey (NHMS) in 2011. This could be due to the different tools used: MINI as a diagnostic tool was used in the NHMS 2011 while DASS-21 as a screening tool was used to assess risk for depression among our participants. Depression was independently associated with vitamin D status. In general, our participants at risk for depression had almost twice the odds of vitamin D deficiency compared with their counterparts, in line with Jozefowicz *et al.*'s study[40]. Vitamin D receptors are found in the brain and there may be more than one pathway that explains this relationship[41]. Receptors for vitamin D are present on neurons and glia in many areas of the brain including the cingulate cortex and hippocampus, which have been implicated in the pathophysiology of depression[42]. Vitamin D is involved in numerous brain processes including neuroimmunomodulation, regulation of neurotrophic factors, neuroprotection, neuroplasticity and brain development[43], making it biologically plausible that this vitamin might be associated with depression. Other proposed biological mechanisms may be that vitamin D impacts innate immunity and the production of pro-inflammatory cytokines, which in turn influences mood by activating the stress response[44]. Our results are consistent with the hypothesis that low vitamin D concentration is associated with depression; however, there is a need for randomized controlled trials or longitudinal studies[13,45] to determine whether the association is causal.

There was a significant inverse association of vitamin D deficiency with mental health-related quality of life (MCS), while no association was observed between physical health-related quality of life (PCS) scores and vitamin D deficiency, in line with a study by Anand *et al.*[46]. Individuals who are at risk for depression may be at higher risk for poorer mental health[39]. On the other hand, another study found vitamin D deficiency was associated with both mental and physical component scores among their female participants with weakness, fatigue and non-specific pain[14]. Although non-specific muscle and bone pain has frequently been reported by patients or the elderly with low vitamin D status[13], we did not observe such associations among our participants. This could be explained by the fact that our participants were relatively young (mean age of 41·15 (95% CI 40·51, 41·78) years) and they were a working cohort who were healthier than those not working, as reflected by their low prevalence of diabetes mellitus and hypertension compared with the general population[9]. However, if their status of vitamin D deficiency is not corrected, there is the possibility of them developing the above symptoms in the future and eventually having poorer physical health.

There are some limitations which warrant discussion while interpreting the findings. As all our participants were teachers, our results may be generalized only to other women with similar working conditions and demographic profiles such as office workers. The non-representativeness of ethnic distribution and higher education level may limit the generalization of our findings to the general female population. The cross-sectional nature of our study prevents us from establishing causality between vitamin D status and depression or mental health-related quality of life. Further, although we did adjust for the confounding effect of race, age group, MetS, BMI, PTH and physical health-related quality of life (PCS), we acknowledge that other factors may have confounded the observed association of 25(OH)D with depression and mental health-related quality of life. A final limitation relates to the use of self-reported DASS-21 and SF12v2; although both are established and validated instruments, reporting bias may arise given that both instruments were self-perceived.

On the other hand, our study may be the first among tropical countries providing information on the association of depression and mental health-related quality of life with vitamin D status concurrently. Previous studies in the West found vitamin D deficiency to be associated with depression; however, there was a gap in this aspect among populations from tropical countries. Our findings showed that vitamin D is associated with depression and mental health-related quality of life among women from an urban community in a tropical country with an abundance of sunshine.

This widespread vitamin D deficiency among middle-aged women is an urgent health issue that needs to be remedied, especially since it is prevalent among women who will be at risk of postmenopausal osteoporosis as they age. Our participants, who are female teachers with roles as caregivers of their families and educators for the future generation, should be in optimum health in order to perform their tasks efficiently. Therefore, it is important that they are aware of their vitamin D status and take preventive measures if need be, as vitamin D deficiency may be undiagnosed if no screening tests are carried out. Our results provide a rational basis for targeted public health prevention programmes in the tropics that focus on high-risk ethnic groups, women and those with depression. Public health authorities should consider routine screening of vitamin D status, increasing food fortification programmes with vitamin D, sensible sun exposure recommendations and encouraging ingestion of vitamin D supplements when needed.

Conclusion

A high proportion of our participants had vitamin D deficiency and abnormal depression scores. Ethnic Malay and Indian women were more susceptible to vitamin D deficiency. We conclude that vitamin D status is significantly associated with depression as well as mental health-related quality of life among women in Kuala Lumpur, Malaysia. Longitudinal studies should be carried out among populations which have more diverse occupations, education levels and representative ethnic distributions.

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