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Associations with Vitamin D deficiency in "at risk" Australians☆

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Abstract

In a study of 185 elderly living in assisted care and 192 frail aged living in the community in the Sydney metropolitan area, nursing home residents were found to be at a 3-fold and hostel dwellers at a 2-fold risk of Vitamin D [25(OH)D] deficiency (<25 nmol/L) compared to self care residents. Middle Eastern people were found to be at 4-fold risk and Vietnamese a 3-fold risk of deficiency compared to their Australian counterparts. In recently arrived Chinese immigrants, Vitamin D deficiency, was found in 28%, and marginal levels (<37 nmol/L) in 60%, compared to the 34 and 76% found in our nursing home population, and 25 and 57% in hostel care residents. Of the Middle Eastern elderly, 58% were deficient and 83% marginal; although only 18% of Vietnamese were deficient, 68% had marginal Vitamin D status. Other factors associated with Vitamin D deficiency were mobility and sun exposure in assisted care, and low dietary Vitamin D and calcium intake, reduced exercise levels and high % body fat levels in the immigrant groups.

Keywords: Vitamin D; Immigrants; Nursing home; Sunlight; Body fat; Vietnamese; Middle Eastern; Chinese; Australian

1. Introduction

Over the last 30 years, low Vitamin D status among housebound elderly and Asians has been reported in many countries [1,2], and most recently in Australia [3,4]. We have investigated the prevalence of Vitamin D deficiency in elderly people in nursing homes, hostels and under self-care, and also aged free living Asian and Middle Eastern immigrants. In addition, in light of a recently published study [5] from Australia reporting low Vitamin D status in Beijing adolescents, we included Chinese immigrant women living in Australia in this survey.

2. Methodology

2.1. Study design

There were three different population groups in this overall investigation of risk factors associated with Vitamin D deficiency (assessed by measuring blood concentration of 25-hydroxy-Vitamin D[25(OH)D]): Group 1 was 185 randomly chosen elderly Caucasians living in assisted care: nursing-homes, hostels or self care units:

Group 2 was 192 elderly frail-aged people from volunteer community elderly groups of Vietnamese, Middle Eastern, Northern European and Australian. In addition two sunlight intervention studies were conducted over 3 weeks for 2 h per day on subgroups: 28 Vietnamese, 17 Middle Eastern and 10 Australian-born.

Group 3 was 60 recently arrived young-middle-aged Chinese women who volunteered from a community Chinese language school.

2.2. Study measures

Anthropometric measures, lifestyle factors and a 24 h validated dietary recall were recorded in all three studies [6,7] sun exposure by validated sun stickers (semi-quantitative personal UV light dosimeter) over 3–7 days and muscle strength by dynanometer measurements in the assisted care and ethnic elderly studies [6,7]. Blood levels of 25(OH)D were determined in fasting plasma obtained from 10 ml blood samples either by a modified competitive-protein-binding assay [8] or a radioimmunoassay [Diasorin Stillwater Minnesota, USA] to assess Vitamin D status (these assays have been cross-validated). In both assay procedures three quality control samples of low, medium, and high concentrations were analysed in each

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run and inter and intra CVs were 12.5 and 5, respectively. The normal range of 25(OH)D is 60–150 nm/L; levels below 25 nm/L were considered to indicate Vitamin D deficiency, while those below 37 nmol/L were interpreted as marginal Vitamin D status. Total cholesterol and triglyceride were measured using a Boehringher Reflotron analyser. Apolipoproteins A (Apo A) and B (Apo B) were analysed using a Turbitime System analyser. Skinfold thickness was measured by using Harpenden callipers at four sites: biceps, triceps, subscapular and supra-iliac. These values were then entered into a predetermined model in order to calculate total body fat percentage (%TBF). Body Mass Index (BMI) was calculated from weight, height measurements: $BMI = Wt/Ht^2$. Both descriptive statistics, Student's *t*-test and logistic analyses (risk estimates with 95% confidence limits) were performed with the aid of SPSS. The effect of confounding factors was assessed by entering variables into a logistic model.

3. Results

3.1. Risk factors associated with Vitamin D deficiency in Sydney elderly

Vitamin D status at the end of summer was <25 nmol/L in 28% of the total sample (mean: 36 ± 19; range 4–120 nmol/L). Table 1 presents these data in comparison to other factors which varied by type of accommodation. These were age, gender, mobility, muscle strength and sun exposure. Those in self care were 4 (2.2–8.0) times more likely to have more than minimal sun exposure than those in Hostels or Nursing Homes. Mobility levels also varied with residence type. These same factors were independently associated with Vitamin D deficiency: those who could not walk unaided had 11.4 (5.6–23.0) times the risk of low Vitamin D status, compared with those who were independently mobile; similarly higher age >80 years versus <80 years had 2.3 (1.2–4.2) times risk; female versus male, 2.4 (1.1–4.9) risk; low muscle strength: low versus other 6.3 (1.2–32) risk in men; low sun exposure: low versus adequate were at 3.0 (1.6–6.6) fold risk. However, vitamin supplementation, diabetic status, dietary Vitamin D and calcium intake and muscle strength (females) were found not to be independently associated with Vitamin D status in this population. Nursing home residents were 3 times (1.3–7.0) and, Hostel residents 2.3 times (1.2–4.3) more likely to have low Vitamin D status than self care residents. These risks stayed the same when the effect of age, gender, dietary and vitamin intake or diabetic status were taken into account. However, the risks became non-significant when exposure to sunlight and mobility status were investigated. This may indicate that lack of exposure to sunlight was the probable cause of the nursing home and hostel Vitamin D deficiency. In fact the smokers in the nursing homes (who are required to smoke out of doors) had mean levels of 37 ± 15 compared to 33 ± 18 nmol/L.

3.2. Risk factors associated with Vitamin D deficiency in Australian ethnic elderly

Vitamin D status at the end of summer was lower in Middle Eastern and Vietnamese free living elderly than their Australian or Northern European born counterparts (Table 2). In fact, Middle Eastern elderly were 3.5 (1.4–9.0) times and Vietnamese 2.6 (1.1–6.9) times more likely to have marginal Vitamin D status (<37 nmol/L) than their Australian counterparts. When dietary and anthropometric factors were investigated, Vietnamese had lower body mass index and dietary calcium intake, and exercised and smoked more than Australians. The subjects of Middle Eastern origin consumed more dairy products and alcohol, smoked more and had a higher % body fat. When investigated independently for association with Vitamin D deficient status: those who had low dietary Vitamin D intake (<5 ug per day) were at 1.7 (1.0–15) the risk and those consuming less than 700 mg of Ca per day were at a 7- (1.0–18.4) fold risk. Those Middle Eastern who had minimal sun exposure were at a 6.5 (1.8–23.2) age adjusted risk of deficiency. Interestingly, there was a (non-significant due to small sample size) consistent tendency for those with more body fat to have lower Vitamin D status with those with BMI >30 at 4- (0.7–12.10) fold risk and those with more than 35% body fat at 2- (0.4–12) fold and those with low HDL plasma levels were at 1.5 (0.6–6.0) risk of deficiency. When the Vietnamese data were investigated in a similar manner, the

Table 1
Risk factors associated with residential status in Sydney elderly

Risk factors	Nursing home, NH $n = 81$ (%)	Hostel, H $n = 55$ (%)	Self care, $n = 50$ (%)	NH, H vs. Self care *($P < 0.05$)
Vitamin D mean ± S.D. (nmol/l)	33 ± 18	36 ± 16	44 ± 24	
Low Vitamin D status <25 nmol/l	34	25	18	**
Borderline Vitamin D status <37 nmol/l	72	58	48	**
Age > 80 years	47	49	34	**
Gender male	43	16	40	ns *
Mobility walk alone	20	54	97	**
Low muscle strength M < 20	66	10	10	* ns
Low muscle strength F < 20	63	52	27	**
Low sun exposure < 35 mJ/cm^2	47	18	0	**

Table 2
Risk factors associated with ethnic status in the elderly

Risk factor	Australian $n = 70$ AUST	N European $n = 31$ NEUROP	Vietnamese $n = 57$ VIET	Middle East $n = 34$ ME	NE, VIET, ME vs. AUST
Vitamin D mean ± S.D. (nmol/l)	33 ± 18	44 ± 27	39 ±14	21 ± 20	ns ns *
Vitamin D status <25 nmol/l	14.5	23	18	58	ns ns *
Vitamin D status <37 nmol/l	38	36	63	88	ns **
Age > 75 years	78	68	14	20	ns **
HDL < 1.0 mmol/L	17	23	32	49	ns **
Dietary Vitamin D intake < 5 μg	34	26	42	56	ns **
Dietary calcium < 750 mg	17	22	48	35	ns **
Dairy intake > 2 L per week	67	58	30	42	ns **
Sun exposure < 35 mJ/cm^2	22	6	16	21	* ns ns
Body mass index (>30 kg/m^2)	14	68	4	48	***
% Body fat > 35	52	46	36	42	ns * ns
Exercise >7 h per week	43	7	52	23	* ns ns

* $p < 0.05$, ns $p > 0.05$.

only factor which remained as a significant independent risk factor was lack of regular vigorous exercise which gave a 3-(1.0 = 9.0) fold odds for deficient Vitamin D status. However, none of these differences easily explained the ethnic differences in low Vitamin D status. We further tested in our supposition that the differences by ethnic background may be explained by cultural differences in exposure of skin to the sun and skin pigmentation: in 28 Vietnamese elderly who were asked to expose their skin to the sun for over two hours per day for 3 weeks at the end of summer we found an average rise of 6 nmol/L (range 0–24). In contrast, a similar exposure in 17 Middle Eastern and 10 Australian elderly found no net increase in Vitamin D levels in an identical study design. It should be noted that the subgroup of Vietnamese were younger, healthier and exercised more than the other frail aged groups.

3.3. Risk factors associated with Vitamin D deficiency in Chinese born women

Vitamin D deficiency was found in 27% and marginal Vitamin D status in 60% of these women who had a mean of 36 ± 14 nmol/L. The length of time spent in Australia for the 60 Chinese women ranged from 0.3 to 18 years; 72% of this population resided in Australia for more than 2 years and 47% for more than 5 years. Other factors associated with Vitamin D status are presented in Table 3. Those who resided longer in Australia were at more risk of deficiency (those resident for 10 years having a mean value of 20.2 ± 6.9 nmol/L). Length of residence in Australia was not associated with any other risk factor. Deficiency was also associated with lack of exercise, low dairy and calcium intake; women who reported no exercise were at a 8.6-fold risk of deficiency compared with those who had some exercise; those consuming <3 serves of dairy a day were at 5.6 times the risk of deficiency, which is similar to the risk of deficiency of those consuming <200 mg of Ca which was a 2-fold deficiency risk. Vitamin D deficiency appears to be positively correlated with overall calorie or fat consumption. This correlation was also found consistently between independent measures of an atherogenic profile and Vitamin D deficiency levels: those with Apolipoprotein B above the mean (100 mg/dL) were 9 times more likely to be deficient than those below the mean. A non significant trend (as above in Middle Eastern) was reflected in positive non significant risk measures (i.e. higher % body fat, more deficiency) as risks of 2 and 7, respectively (Table 3).

Table 3
Risk factors associated with Vitamin D deficiency in Chinese born women

Risk factor	n	Vitamin D (nmol/L ± S.D.)	Deficiency risk (< 25 nmol/L) (95% CI)	Age adjusted deficiency risk (95% CI)
Age < 35 years vs. > 35 years	35	32.3 ± 14.3	7.7 (1.6–38)*	
Residence in Australia > 10 years vs. < 10 years	5	20.2 ± 6.9	14.3 (1.5–140)*	11.8 (1.2–118)*
Exercise no. vs. yes	43	33.7 ± 13.9	8.6 (1.0–71)*	7.4 (1.0–63)*
BMI (wt/ht^2) >25 vs. <25	11	35.9 ± 14	1.8 (0.3–9.4)	2.1 (0.4–12.5)
TBF *(skinfold) >37% vs. <37%	27	34.1 ± 15.0	1.9 (0.6–5.9)	7.1 (1.4–35.8)*
Saturated dietary fat >20 mg vs. <20 mg per day	35	31.9 ± 14.4	3.2 (1.0–10.6)*	3.7 (1.0–13.3)*
Total energy dietary intake >mean vs. <mean (500 kJ)	30	32.4 ± 13.9	14.3 (1.5–140)*	11.8 (1.2–118)*
Apolipoprotein B >100 mg vs. <100 mg	31	29.9 ± 12.9	11.1 (2.2–55)*	9.1 (1.8–46)*
Triglycerides >1 mg vs. <1 mg	32	32.5 ± 13.9	3.5 (1.0–11.8)*	2.4 (0.6–9.2)

* $p < 0.05$.

Table 4
Comparative studies of Vitamin D status [2000 →]

Author	Country Age (mean, range)	Population Sample Size	Vitamin D ± SD(nmol/L) Assay Method[a]	Vitamin D % Deficient[b]	 Marginal[c]
Present Study	Australia (NSW)	Community frail aged			
		N European 31	44 ± 27	23	36
		Australian born 70	33 ± 18	15	23
Looker [9]	NHANES 111 USA	Community census (winter)			
	40-59	M 864 F 959	M 71 F 62	M 2 F 3	M 9 F 17
	60-79	M 827 F 757	M 73 F 64	M 1 F 5	M 7 F 15
	80 +	M 204 F 208	M 69 F 60	M 3 F 5	M 12 F 18
Vasikaran [12]	Australia (SA)	Perth blood donors			
	<60 (18-76)	197	58 ± 19		34
Pasco [14]	Australia (VIC)	Osteoporosis study	S 81 (78-84)	S3	S17
	80	861	W 59 (56-61)	W11	W43
McGrath [17]	Australia (OLD)	Random community			
	42	M 222	M 72 ± 26	8	23
		F 192	F 66 ± 26		
Inderjeeth [16]	Australia (TAS)	Free living elderly			
	75	52	47 ± 24	17	
Present Study	Australia (NSW)	Randomly collected			
	80	Nursing home 81	33 ±18	34	72
	80	Hostel 55	36 ± 16	25	58
	79	Self care 50	44 ± 24	18	48
Sambrook [10]	Australia (NSW)	Age care facilities			
	84	386	17 ± 12	M 68 F 86	
Inderjeeth [16]	Australia (TAS)	Hospitalized			
	81	109	27 ± 17	67	
Nashimoto [33]	Japan	Nursing home residents			
	85	107	30 ± 16	58	
Yamashita [34]	Japan	Primary hyperthyroid patients			
	58	F 65	37 ± 16	32	70
Present study	Australia (NSW)	Volunteer frail aged free living Middle Eastern			
	70	34	21 ± 20	58	88
Nozza [30]	Australia (VIC)	Immigrant			
		31 Mothers	20	81	90
		55 Children	9		
Looker [9]	NHANES III USA	Community census (winter)			
	30-56	M 329 F 323	M 76 F 66	M 5	F 10
	60 +	M 182 F 336	M 83 F 65	M 4	F 12
Glerup [20]	Denmark	Random Moslem Women			
	36	Danish F 40	47 ± 5		
	37	Danish Moslem 100	18 ± 2		
	32	Arab veiled 60	7 ± 1		
Guzel [28]	Turkey				
	16	Veiled (for at least 3 years) 32	83 ± 40	none	none
	16	Unveiled 30	135 ± 68		

Table 4 (*Continued*)

Author	Country Age (mean, range)	Population Sample Size	Vitamin D ± SD(nmol/L) Assay Method[a]	Vitamin D % Deficient[b]	Marginal[c]
Nukamed [29]	Israel	Women after childbirth			
	31	Jewish Orthodox	46 ± 15	3	14
	27	Non Orthodox	34 ± 18	6	33
Mishal [48]	Jordan	21 western F	37 ± 6 S 31 ± 5 W	69 S 12 W	31 S 75 W
	18-45	80 p veiled F	28 ± 4 24 ± 4	45 22	55 78
		23 fully veiled F	24 ± 6 23 ± 3	17 18	83 82
		22 M	44 ± 5 35 ± 4	46 46	18 46
Alagol [23]	Turkey	Pre-menopausal women	Dress		
	14-44	48	Western 56 ± 41	44	
			Traditional 32 ± 24	60	
			Islamic 9 ± 6	100	
Present Study	Australia (NSW)	Community Vietnamese volunteer			
	68	57	39 ± 14	18	63
Iqbal [24]	UK	Indian Asian family members			
	(12-73)	15 M 21 F	All < 15 Assay HPLC	67	
Datta [25]	UK	Intervention trial	14.5 ± 2.3 (pre intervention)		
	Pregnant women	160 non-European	29 ± 9 (post intervention)	50	
Serhan [27]	UK	Indo Asian rheumotology			
	51	Clinic 110	10 ± 5	70	
Islam [32]	Bangladesh	Cross-sectional women			
	28	Urban 90	45 ± 15	17	50
		Rural 99	34 ± 10	12	38
Goswami [31]	Dehli	Volunteers	W		
	23	19 hosp staff (11 M)	8 ± 3		
	24	31 soldiers (M)	47 ± 12		
	43	15 depigmented	18 ± 11		
	23	29 pregnant	22 ± 10		
Present study	Australia (NSW)	Community Chinese			
	60	Women	36 ± 14	28	60
Du [5]	N China (Beijing)	Random school girls			
	13	1248	26 ± 19 S 13 ± 7 W Assay [8]	7 S 45 W	
Yan [38]	N China	Cross sectional community			
	25-35	48 M 48 F	All < 15	29 M 13 F	
	65-75	50 M 48 F	Winter- Late Spring	48 M 15 F	
Lee [42]	N China (Beijing)	Random school girls			
	9 – 17	12	31 ± 10		
Soontrapa [37]	Thailand	Volunteer elderly urban women			
	70	106	70 ± 7	35	65
Nakamura [35]	Japan	Young adult women			
	19 – 24	77	< 30 34 ± 11 > 30 50 ± 14	42 10	

S: summer, W: winter, F: female, M: male.

[a] Radioimmunoassay unless specified.

[b] Deficient < 25–30 nmol/L.

[c] Marginal < 37–50 nmol/L.

4. Discussion

A summary table of relevant comparison studies is presented in Table 4.

4.1. Risk factors associated with residential status in Sydney elderly

As has been hypothesised in other Australian studies [10,11,13,15,18] and internationally [19–23] sun-exposure was the environmental factor which best explained the association of low Vitamin D status with type of accommodation. Also, in agreement with other studies [21] independently mobile subjects, regardless of their place of residence, had higher Vitamin D levels and greater sun exposure than those with restricted mobility. Subjects with restricted mobility also had lower muscle strength than their mobile counterparts. Thus, the risk factors identified were limited mobility and lack of exposure to sunlight.

4.2. Risk factors associated with ethnic status in the elderly

Our findings of very low Vitamin D levels in immigrant elderly are consistent with a growing literature on this phenomenum world wide [2,3,21]. Since the late 1970s reports of rickets in children of Asian Indians in the UK have continued and of late, deficiency in adults [24,25,27]. Although some surveys from Middle Eastern countries [28,29] report adequate Vitamin D status reports of frank deficiency in the Middle East and on immigration to the Netherlands and Scandinavia are similar to our observations [19,21,23,30]. The low Vitamin D status of immigrant Middle Eastern and Vietnamese was variably associated with measures of sun exposure; by UV monitoring badges in the Middle Eastern elderly and by a sun intervention sub-study in the Vietnamese. These observations confirm recent Australian observations in pregnant women [26]. Other reports have also suggested that lack of adequate dietary Vitamin D and calcium and reduced outdoor activity may have a role to play in the Vitamin D deficiency status in these populations [3,4].

4.3. Risk factors associated with Vitamin D deficiency in Chinese-born women

Vitamin D deficiency has been reported recently in China in both adults and children [5,38,42]. Two studies of Asian elderly [33,34] reported deficiency status, however, most earlier population studies in China (Hong Kong [40], $n = 62$ mean $= 82 \pm 20$; Taipei [39], 262 mean $= 75 \pm 20$ and Hong Kong [41] hip fracture $n = 200$ mean $= 75 \pm 20$ controls 427 mean $= 80 \pm 23$ nmol/L) investigating Vitamin D status report much higher Vitamin D levels than found in India [31] or Bangladesh [32] or this present study. A small study of young women [38] reports similar deficiencies to our findings but larger elderly community surveys from Japan [36] and Thailand [37] have adequate levels. Studies conducted in China reported no age related decline in Vitamin D status [39–42]. Low levels of calcium intake and a relationship between increased exercise levels and apolipoprotein B levels, were also reported, [43,44,46]. Despite intensive investigation there has been no association found between Vitamin D receptor genotype and peak bone mass [45]. The consequences of Vitamin D deficiency status in these populations is still in debate [43].

5. Conclusion

As all these studies were cross sectional and of limited sample size it is impossible to disentangle causation and other unrelated factors. Further studies investigating sun exposure and dietary intake are needed: qualitatively, to investigate the cultural barriers to sun exposure and dietary intervention and quantitatively, to investigate the possibility of sunlight intervention studies in these “at risk” populations In addition, further metabolic investigations of the intriguing relationship between low Vitamin D and increased fat consumption and lipid levels are needed. Need et al. [18] recently reported increased % body fat associated with low Vitamin D status and hypothesised that storage in fat may limit available Vitamin D levels in the blood. Despite these limitations, such data do indicate the potential to identify “at risk” populations in Australia such as housebound elderly, Middle Eastern and Vietnamese and, recent Asian immigrants in Australia. All these populations are known to have low sun exposure or cover themselves when exposed to the sunlight.

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