Short Communication

Serum 25-hydroxyvitamin D concentration of Indigenous-Fijian and Fijian-Indian women

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Background: Serum 25-hydroxyvitamin D (25OHD) concentrations are lower in Pacific people compared to Caucasians living in New Zealand. However, there are no data on the 25OHD concentrations of Pacific people living in the Pacific Islands. Aim: To assess the vitamin D status of indigenous and Indian Fijian women living in Fiji by measuring 25OHD concentrations. Methods: 25OHD concentrations in a national sample of 511 Fijian women (15-44 y). Results: The mean 25OHD concentration of Fijian women was 76 nmol/L (95% CI: 73, 78). 25OHD was lower in Fijian Indian [70 (66, 74) nmol/L; n=205] women compared to indigenous Fijians [80 (76, 84) nmol/L; n=306] (p<0.0001). The mean 25OHD was higher in rural [77 (74, 80) nmol/L; n=392] than urban [70 (65, 76) nmol/L; n=119] women (p<0.0001). Body mass index (BMI) and age were not predictors of 25OHD concentrations. Of Fijian females, 3%, 11%, and 56% had 25OHD concentrations indicative of 25OHD insufficiency using cut-offs of ≤37.5, ≤50 and ≤80 nmol/L, respectively. Conclusion: Mean 25OHD in Fijian women was generally adequate and exceed concentrations reported in Pacific females living in New Zealand.

Key Words: vitamin D status, women, Fijian, Indigenous, Indian

INTRODUCTION

Vitamin D inadequacy increases bone fragility, and maintaining adequate vitamin D status throughout life may reduce the risk of osteoporotic fractures.[1] Recent evidence has suggested that vitamin D may also be involved in the aetiology of non-communicable diseases, such as type 1 diabetes, certain cancers, cardiovascular disease and autoimmune disorders.[1-3] While we obtain a small amount of vitamin D from dietary sources, the majority of vitamin D is synthesised in the skin by the action of ultraviolet B light on 7-dehydrocholesterol.[2] Serum 25 hydroxyvitamin D (25OHD) is the best indicator of vitamin D status. A major determinant of 25OHD is skin colour; people with highly pigmented skin need more sun exposure to produce the same amount of vitamin D than people with lightly pigmented skin.[2,4,5] Lower serum 25OHD concentrations in darker skinned ethnic groups, compared to lighter skinned groups, living in the same geographical area are well documented.[6]

Recently, we measured serum 25OHD concentrations of New Zealander's in two national surveys, one of school-aged children and the other of adults.[7,8] Mean serum 25OHD concentrations were approximately 50 nmol/L, in both children and adults, with over 50 percent of individuals classified as vitamin D insufficient (< 50 nmol/L). Ethnicity was a major determinant of 25OHD concentrations. Notably, Pacific people had serum 25OHD around 14 nmol/L lower than New Zealand Europeans probably due to their darker skin colour. An important question to answer is whether Pacific people living in New Zealand have poorer vitamin D status than those living in the Pacific Islands. Given New Zealand's cooler temperatures, less sunlight hours and lower latitude, in comparison to the Pacific Islands, one might predict Pacific people living in the islands to have much better vitamin D status than their New Zealand counterparts. Previous investigators, who have explored the effects of migration to higher latitude, and a more temperate climate, on vitamin D, reported a decrease in serum 25OHD concentrations.[9]

To address the hypothesis that Pacific people in the Pacific Islands have higher vitamin D status than Pacific people in New Zealand, we measured the vitamin D status of participants in the 2004 Fiji National Nutrition Survey (FNNS, 2004). As part of this survey, serum samples were collected from women of childbearing age (15-44 years)**.** Fiji has two major ethnic groups, indigenous Fijians and Fijian Indians, both of whom participated in the survey. Indian Fijians make up about 38% of the

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population and are concentrated in cities and towns on the northern and western coasts of Viti Levu and Vanua Levu.[10] Therefore, the survey provides a unique opportunity to examine the vitamin D status of another migrant population. Despite India's close proximity to the equator (8°N-37°N) the rate of serum 25OHD insufficiency is great; in one study, 70 percent of rural and 75 percent of urban women were classified as insufficient in terms of serum 25OHD (<50 nmol/L).[11] The aim of the present study was to assess the vitamin D status of indigenous Fijian and Fijian Indian women by measuring serum 25OHD.

MATERIALS AND METHODS

Study design and population

The third Fiji National Nutrition Survey was a cross sectional population based survey of Fijians. A two stage cluster sampling method was used to recruit participants from 38 households, within each of the 45 census determined enumeration areas, across four administrative divisions within the Republic of Fiji Islands. There was no over-sampling of either ethnic group. Data and blood collection took place from May to September 2004, during the Fijian Winter. Informed consent was requested from household members prior to participation in the survey. Ethnicity was self-reported. Height and weight were measured using standardized techniques. All participants were classified using World Health Organization (WHO) BMI criteria: participants with a BMI (kg/m^2) ≤18.49 were classified as underweight, 18.5 - 24.9 were classified as normal weight, 25 - 29.9 were classified as overweight and those with a BMI ≥30 were classified as obese.

A total of 1696 households were surveyed and a total of 7372 persons agreed to participate, resulting in a response rate of 87%. Blood samples where collected for micronutrient assessment from women of reproductive age only. Nine hundred and ninety seven females from 1503 households were eligible to provide blood samples. Of the 997 women selected, 758 provided blood samples, resulting in a response rate of 76%. Women were excluded if they were pregnant (n=5) or not within the child bearing age range of 15-44 years (n=8). Serum 25OHD concentrations were measured for 511 females, who had all relevant data available for this study.

Blood Collection and Analysis

Venous non-fasting blood samples (10 ml) were collected, using a vacutainer, or disposable needles or syringes, between 9 am and 1 pm at either the hospital, health centre, nursing station, or village community halls. Samples collected from health centres were stored in cold boxes and transported to the main hospital in the area, where they were centrifuged, and stored at -20 °C, after which serum samples were stored at -40 °C. The samples were stored for three years before analysis for 25OHD. Serum 25OHD concentrations in blood were determined at the University of Otago New Zealand using radioimmunoassay kits (DiaSorin Stillwater, MN). The same method and lab measured the 25OHD concentrations in both Fiji and the New Zealand surveys. Two levels of controls provided by the manufacturer were run in each assay. The inter-assay coefficient of variation based on repeated analysis of pooled controls for vitamin D was 12 %. To verify the relative accuracy of our results, we sent aliquots of 20 randomly selected samples to the Steroid Laboratory of Canterbury Health Laboratories. This laboratory, using the same method, reported a mean serum 25-hydroxyvitamin D concentration of 51 nmol/L, compared with our measured mean of 53 nmol/L. Three 25OHD cut-offs were used to define insufficiency: ≤37.5 nmol/L, ≤50 nmol/L, and ≤80 nmol/L.[12]

Statistical Analyses

All statistical analyses were performed using STATA 9.0 (2005, Statacorp, College Station, TX). We included in our analysis only those participants with known serum 25OHD concentrations, who were of Indigenous Fijian or Fijian Indian ethnicity (excluded "other" ethnicity n = 8), who had available BMI measurements (n = 538), who were of reproductive age (15-44 years) (excluded n = 8), and who were not pregnant (excluded n = 5). Participants with 25OHD concentrations above 200 nmol/L were also excluded because this was above the upper detection limits of the assay (n = 17). The log transformation of 25OHD was calculated to meet the assumptions of the linear regression model and thus data are presented as geometric means. Associations were considered significant at a 95 % level. Linear regression was used to calculate the unadjusted means of age (15-19, 20-24, 25-29, 30-34, 35-39, 40-44 years), ethnicity (indigenous Fijian, Fijian Indian), region (urban, rural), and BMI (≤18.49, 18.5 - 24.9, 25 -29.9, ≥30 kg/m^2), regardless of their level of statistical significance. A multiple linear regression model was used to examine the independent relationships between these variables and serum 25OHD (adjusted).

RESULTS

Serum 25OHD concentration was available for a total of 511 female participants; 306 indigenous Fijians (60%), and 206 Fijian Indians (40%) (Table 1). Of the participants, 76.7 % were from rural areas of Fiji. Of indigenous

Table 1. Descriptive characteristics of participants

Characteristic	Women with a 25(OH)D
Number of participants	511
Age category n (%)	
15-19	39 (7.60)
20-24	89 (17.4)
25-29	97 (19.0)
30-34	102 (20.0)
35-39	87 (17.0)
40-44	97 (19.0)
Ethnicity n (%)	
Indigenous Fijian	306 (59.9)
Fijian Indian	205 (40.1)
Region n (%)	
Urban	119 (23.3)
Rural	392 (76.7)
Body Mass Index n (%)	
≤ 18.49 kg/m^2	29 (5.70)
18.5 - 24.9 kg/m^2	173 (33.9)
25 - 29.9 kg/m^2	175 (34.3)
30 + kg/m^2	134 (26.2)

25(OH)D, Serum 25 hydroxyvitamin D

Fijian women, 69% resided in rural areas (n = 272); in contrast, 71 % of Fijian Indians resided in urban areas (n = 85). The mean age of participants (31 years) was similar in both ethnicities: 30 years (SD = 8) for Indigenous Fijians, and 32 years (SD = 8) for Fijian Indians. The mean BMI for the survey population was 26.6, ranging from 14.8 to 45.6. Thirty four percent of all participants were overweight and a further 26 % were obese, as classified by the WHO cut-offs. The prevalence of overweight was higher in Indigenous Fijians (35.9%), in comparison to Fijian Indians (31.7%).

The unadjusted results did not differ greatly from adjusted results, thus only adjusted data are presented. Adjusted geometric mean serum 25OHD concentration by ethnicity, age, region, BMI, and the proportions of participants with serum 25OHD concentrations (nmol/L) under three specified cut-offs: ≤37.5, ≤50, and ≤80 are shown in Table 2. The mean 25OHD concentration of Fijian women was 76 nmol/L (95% CI: 73, 78). The mean serum 25OHD concentration was significantly lower in Fijian Indian women compared to indigenous Fijian women [10 (95% CI: 4, 15) nmol/L] (p<0.0001). Mean 25OHD concentrations were significantly higher (p <0.0001) in rural women in comparison to urban women [7 (95% CI: 0.6, 14) nmol/L]. Age and BMI category was not a significant determinant of 25OHD concentrations. Three percent of the total survey population had serum 25OHD concentrations below 37.5 nmol/L. The proportion of participants with 25OHD below 37.5 nmol/L ranged from 2% in rural women and indigenous Fijian women, to 5% in urban and Indian women. Eleven percent of all participants had a mean 25OHD concentration below 50 nmol/L (95% CI: 9, 15), and 56% (95% CI: 52, 61) of all women had 25OHD levels below 80 nmol/L. Urban women had the highest prevalence of 25OHD insufficiency as measured by the three cut-offs.

DISCUSSION

Our results suggest that the vitamin D status of Fijian women of childbearing age is generally adequate. The mean serum 25OHD concentration was 76 nmol/L and only 11% of women had serum 25OHD concentrations below 50 nmol/L. In the present study a major determinant of 25OHD concentration was ethnicity (p<0.0001); Fijian Indians had lower mean 25OHD concentrations (70 nmol/L) than indigenous Fijians (80 nmol/L). Fijian Indians may have greater skin pigmentation in comparison to Indigenous Fijians. Greater skin pigmentation reduces cutaneous synthesis of vitamin D.[6,9,13,14] Fijian Indians are also more likely reside in urban areas and may have different dress and social customs from the indigenous Fijians, which may explain their lower 25OHD concentrations. Despite having only a 10 nmol/L lower 25OHD than indigenous Fijians, Indians were at three times great risk of having a 25OHD less than 50 nmol/L and this difference may be clinically relevant. The finding that urban women had lower 25OHD concentrations than rural women is similar to previous findings. Urban dwellers may receive less sunlight exposure due to a greater quantity of indoor activities.[11,15] In the present study, a possible explanation for lower 25OHD concentrations among urban women may be the different working environments that include a decrease in outdoor activities, an avoidance of direct sunlight exposure, and varying social and traditional protocols, which may include more conservative and formal dress.

In the present study there was also no association between obesity and serum 25OHD concentrations. Previ-

Table 2. Adjusted geometric mean serum 25-hydroxyvitamin D by ethnicity, age, region, body mass index and the proportion of participants defined as insufficient by three different cut-offs.[†]

	n	Adjusted mean (95% CI)	Proportion insufficient (adjusted) %≤37.5nmol/L (95% CI)	%≤50nmol/L (95% CI)	%≤80nmol/L (95% CI)
All	511	76 (73, 78)	3 (1, 5)	11 (9, 15)	56 (52, 61)
Age					
15-19	39	70 (61, 79)	2 (0.3, 15)	11 (4, 28)	66 (49, 79)
20-24	89	71 (66, 77)	4 (1, 10)	18 (11, 28)	63 (53, 73)
25-29	97	77 (71, 83)	2 (0.7, 8)	11 (6, 19)	55 (45, 65)
30-34	102	76 (70, 82)	2 (0.6, 6)	13 (8, 21)	52 (42, 62)
35-39	87	79 (72, 85)	3 (0.7, 9)	7 (3, 15)	53 (42, 63)
40-44	97	78 (72, 85)	3 (1, 9)	9 (5, 16)	55 (44, 65)
Ethnicity					
Indigenous Fijian	306	80 (76, 84)	2 (0.7, 4)	7 (5, 12)	52 (46, 58)
Fijian Indians	205	70 (66, 74)[*]	5 (2, 10)	21 (18, 39)	62 (55, 69)
Region					
Urban	119	70 (65, 76)	5 (2, 11)	17 (11, 25)	66 (56, 74)
Rural	392	77 (74, 80)[**]	2 (1, 4)	10 (7, 13)	53 (48, 58)
BMI					
≤ 18.49 kg/m^2	29	78 (67, 90)	3 (0.6, 15)	11 (4, 25)	60 (40, 78)
18.5 - 24.9 kg/m^2	173	77 (72, 82)	3 (1, 7)	9 (5, 14)	58 (50, 66)
25 - 29.9 kg/m^2	175	78 (74, 83)	2 (0.8, 6)	11 (7, 17)	49 (42, 57)
30 + kg/m^2	134	71 (66, 76)	3 (1, 8)	15 (10, 24)	62 (53, 70)

[†]Adjusted for age, ethnicity, region, and body mass index
[*]p<0.0001 different from Indigenous Fijians
[**]p<0.0001 different from Urban

ous studies have reported the decrease in serum 25OHD with increasing body fatness.[7,16,17] Arunabh et al[17] in a cross sectional, population based study of healthy African American and Caucasian women concluded that percentage body fat, and not body mass was independently associated with serum 25OHD concentrations in women. Interestingly, Looker[18] found that serum 25OHD varies by race and the affects of body fat percentage are greater in Caucasian females when compared to African Americans. These findings are consistent with those of Scragg *et al*,[19] who found that 25OHD concentrations were unrelated to body mass in a multicultural workforce. Is it possible that the continuous production of vitamin D through UV exposure in Fiji might have masked the relationship between D status and obesity which might only be observed when endogenous vitamin D ceases during winter months at regions further from the equator.

The serum 25OHD status of Fijian women (76 nmol/L) is considerably higher then Pacific females aged 15 years and over, in New Zealand's National Nutrition Survey.[7] In New Zealand, the mean 25OHD concentration was 34 nmol/L, and 79 percent of Pacific females had serum 25OHD concentrations below 50 nmol/L. New Zealand's cooler temperature and higher latitude (Fiji 18°S; NZ 37-47°S) probably explains the differences between the high 25OHD concentrations measured in Fijians in the present study, and the lower concentrations seen in Pacific people in New Zealand. Sunburning UV, averaged over a full year, at the equator is about twice that at mid latitudes. Further, winter UV levels in Rarotonga and the Cook Islands (22°S) were shown to be ~ 6 times greater than in Lauder (45°S) in the South Island of New Zealand.[20]

Indian Fijians have higher 25OHD status in comparison to counterparts living in India.[11,15,21] Harinarayan et al.[(11)] reported that 70 percent of rural and 75 percent of urban women had serum 25OHD concentrations below 50 nmol/L, in comparison to 21 percent of Fijian Indians in the present study. However, despite the differences in the prevalence of 25OHD insufficiency between Indian women and Fijian Indian women, latitudes of Fiji and India are comparable (Fiji 18°S, India 8°N-37°N). This suggests that not only latitude, but also the environment and culture of Fiji, may influence the 25OHD concentrations of Fijian women.

A limitation of our study was that population survey weights were unavailable for the third Fiji National Nutrition Survey and this could affect the accuracy of our population estimate for 25OHD. Region and ethnicity were the determinants of 25OHD in this population. Sixty percent of survey participants were indigenous Fijians compared with 57% in the 1997 Census, indicating that the survey sample was representative with respect to ethnicity. However, only 24% of survey participants lived in a rural setting compared to 50 % in the 1997 Census. Because rural Fijian women had a 7% nmol/L higher 25OHD than urban Fijian women we may have overestimated the overall mean 25OHD for Fijian women by as much as 3%. This difference would not affect the interpretation of the results.

In this study we have provided the first population based survey of Fijian female serum 25OHD concentrations. Mean 25OHD concentrations in Fijian women was generally adequate. Serum 25OHD concentrations of women in this study far exceed the concentrations reported in Pacific females residing in New Zealand, and of Indian women in India. If higher levels of serum 25OHD concentrations, such as those found in the current study, are 'typical' concentrations of 25OHD for Pacific Islanders and indicative of bone health, it indicates that the levels found in Pacific people residing in New Zealand are not adequate.

AUTHOR DISCLOSURES

The authors have no conflicts of interest

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斐濟本地和斐濟/印度婦女的血清25-羥維生素D水平

背景：與居住在新西蘭的白種人相比，太平洋人的血清25-羥維生素D（25OHD）水平較低。盡管如此，並沒有數據顯示在太平洋群島居住的太平洋人的25OHD水平。目的：通過檢測25OHD水平來評估居住在斐濟的本地婦女以及斐濟/印度婦女的維生素D狀況。方法：在全國範圍內抽樣檢測511名斐濟婦女（15-44歲）的25OHD水平。結果：斐濟婦女25OHD的平均值是76 nmol/L （95% CI: 73, 78）。與斐濟本地婦女相比[80(76, 84)nmol/L; n=306],斐濟/印度婦女的25OHD水平更低[70(66, 74)nmol/L; n=205] (p<0.0001)。農村婦女25OHD的平均值[77(74, 80)nmol/L; n=392]高于城市婦女[70(66, 74)nmol/L; n=119] (p<0.0001)。體質指數（BMI-Body Mass Index）和年齡並不能預測25OHD的水平。采用25OHD水平≤37.5，≤50，≤80 nmol/L作爲指標，分別有3%，11%，以及56%的人沒有足夠的25OHD。總結：斐濟婦女25OHD的平均水平普遍達標並且超過居住在新西蘭的太平洋婦女的維生素D水平。

關鍵字：維生素D狀況，婦女，斐濟，本地人，印度人